Sails to Satellites

A history of meteorology in New Zealand

(Alexander Turnbull Library)

'View of Cape Stephens in Cook's Strait'. An engraving after the original oil by W. Hodges (1744–1797), giving the artist's impression of waterspouts and rough weather met on Cook's second voyage.

Sails to Satellites

a history of meteorology in New Zealand

J.F. de Lisle

New Zealand Meteorological Service
Wellington, New Zealand

Published by the New Zealand Meteorological Service
P.O. Box 722, Wellington, New Zealand

First published 1986

Edited and
designed by Richard Heine

Text set 10/12 Century Old Style

National Library of New Zealand Cataloguing in Publication Data

DE LISLE, J. F. (John Felix)
Sails to satellites : a history of meteorology in New Zealand / J. F. de Lisle ; [edited and designed by Richard Heine]. — Wellington, N.Z. : New Zealand Meteorological Service, 1986. — 1 v.
ISBN 0-447-07300-X
551.5060931
1. New Zealand Meteorological Service. 2. Meteorology — New Zealand — History. I. Heine, Richard W. (Richard Werner), 1935- . II. New Zealand Meteorological Service. III. Title.

FOREWORD

The history of mankind abounds with accounts of attempts to influence the weather: in early times through incantations, dances and gifts, and sacrifices to or covenants with, the gods; and in more recent times purposeful alteration of the physical or chemical state of the atmosphere — so intertwined is the life of man with his natural environment.

This universal and primeval interest in natural events, coupled with the insatiable desire of our species to know what lies ahead, pervades the activities of national meteorological services in all countries.

The challenge of weather forecasting has, over the years, been grabbed by optimistic entrepreneurs, courted by courageous but cautious scientists, and scathingly shunned by others. Perhaps the middle ground of these responses is best described in the words of Professor R. S. Scorer, in the preface to his 'Natural Aerodynamics' (1957):

> . . . I must acknowledge debts of gratitude. First to the (UK) Meteorological Office for enrolling me during the War and presenting me with the impossible task of forecasting the weather. It is a stimulating experience for a scientist, more particularly a mathematician, to have to find within a given time, answers to questions which are always beyond his powers but which he instinctively feels ought to be within his grasp.

The scientific approach to practical weather forecasting was in its infancy at the time those words were written. Since that time, progress has matched that of the space age; before that time, it was little more than irregularly glacial.

This book describes some of the people, and the organizations, behind the search for understanding of weather and its vagaries, and the application of this understanding for the benefit of New Zealanders and our Pacific neighbours. It is written at a time when, not only the numbers of those who took part in the major expansion of the Meteorological Service to meet the demands of World War II are decreasing rapidly, but also the present day Meteorological Service, along with most other government departments, is subject to massive changes.

But why write about the past in times of change? Is the past and its experiences the best, or worst, teacher? Does it give us insights and understanding which will be useful in the future, or does it prepare us for situations that have ceased to exist? Conversely, is tradition an essential component of a true democracy in that it is the voice of the past, still with us in the present,

and destined to be with our successors? Since principles of conservation are endemic to the thinking of meteorologists, we see value, and take pride, in our past and present.

This is the story of a pilgrim people, journeying towards the elusive goal of understanding nature, perhaps an understanding that is 'always beyond [our] powers, but which . . . ought to be within [our] grasp.' It is a story that includes, increasingly in later years, a growing regional and global interdependency, and thus a contribution towards the strengthening of international ties and friendship between nations.

Dr John de Lisle is well qualified to write our history. In earlier years a secondary schoolteacher, he joined the Meteorological Branch of the RNZAF in 1942, was later a member of the New Zealand Defence Science Corps, rejoined the Meteorological Service in 1956, was successively a research climatologist, assistant director (research), and from 1973 to 1977 its director.

We are deeply indebted to him for his painstaking 'retirement' activities that resulted in this book.

John S. Hickman
Director of Meteorological Services

19 February 1986

CONTENTS

PREFACE

The New Zealand Meteorological Service had its beginnings in the early years of British colonial rule. Observations of climate had been made by individual European visitors and settlers, and the military forces before a government sponsored meteorological organisation was set up in the Colonial Secretary's Office in 1861. Its aim was to produce consistent climatic data for the whole colony by means of observatories in each province.

Later, the gradual extension of the electric telegraph system made it possible to collect weather reports on a daily basis from the scattered settlements. This enabled the Marine Department, following the example of Admiral FitzRoy at the Board of Trade, London, to begin a storm warning service for shipping in 1874.

The story of the administrative arrangements under which these separate organisations worked before final permanent amalgamation, is a complicated tale. Even after the amalgamation, the Service was shuttled between different government departments. Seven departments, and the Royal New Zealand Air Force have had a hand in the control of meteorology in New Zealand in the last 125 years.

Although often undersupported, the Service was fortunate in the calibre and vision of the scientists who early shaped its future. Sir James Hector in the 1880s, and Sir Ernest Marsden and Dr Edward Kidson at the start of the modern era, had a decisive influence on the direction of meteorology in New Zealand.

In the last thirty years technology has provided meteorologists with sophisticated sensors carried in meteorological satellites, and with high speed computers. Through international co-operation atmospheric data, of a kind and quantity not envisaged a generation ago, is freely available. It is quite natural, nowadays, to take for granted this wealth of information and the technical devices which enable it to be processed. The Service has been able to take advantage of the products of this new technology because of those whose expertise and enthusiasm implemented a complete change in the structure and operations of the Service. Their work would not be possible without their numerous predecessors whose account is given in the following pages.

The primary records of the history of the Service are scattered in the files of government departments, and held in the various institutions listed in the bibliography. There are, however, many tantalising gaps because of losses of early records. I wish to thank the staffs of the National Archives of New Zealand, the Alexander Turnbull Library, and the National

Museum of New Zealand for their help in tracing files and documents. Special thanks are also due to Mr J. S. Hickman, Director of the New Zealand Meteorological Service, for giving me free access to the records of the Service. Gaps in the more recent history have often been filled by ex-colleagues, who patiently and willingly answered my queries. The production of this book also owes much to the work of the staff of the Service, to whom I am grateful.

It had been expected that a history of New Zealand meteorology would have been written by the late Ian S. Kerr, who retired as assistant director in 1978. He had completed a preliminary draft of only two chapters before his death, and I gratefully acknowledge the use of some of his material.

The only previous extensive survey of the early history of the Service is an unpublished university thesis by Dr J. B. Owen who served as a weather forecaster during the 1939-45 War. He also wrote an unpublished war history of the Service. Acknowledgement is made of reference to both of these works. The primary records quoted have been consulted, except in the case of the war history, where some sources have been lost by fire.

The whole of an early draft was read by Dr J. F. Gabites and the first three chapters by Dr A. G. Bagnall, to whom I owe thanks for their suggestions and comments, as well as to the editor Dr R. W. Heine of the Meteorological Service for his cheerful guidance. The Service, which sponsored this book, has had no influence upon the interpretation of the historical events, or the judgements made. These are all my responsibility.

The Service has been known by a variety of titles over the years. The labels Meteorological Department, Weather Signal Department, Weather Forecast Department, Meteorological Office, Meteorological Branch of the RNZAF, and New Zealand Meteorological Service have all been applied at one time or another. Each is used in the following pages where appropriate.

While a list of the main sources consulted has been given there is no detailed referencing. A fully annotated version has been deposited in both the Alexander Turnbull Library and in the Meteorological Service Library.

1
Early observations

In August 1861 the Colonial Secretary of New Zealand, William Fox, wrote to the superintendents of the various Provinces throughout the Colony instructing them to establish observatories to house meteorological instruments, which the Colonial Office would send them. Each province was to appoint someone to record instrumental readings twice a day, note details of the weather and send results at intervals to central Government for collation. The summarised information would enable Meteorological Statistics of New Zealand to be published from time to time.

Dr Charles Knight, the Auditor General, was appointed to control the scheme and soon after was signing correspondence as Director of Meteorological Stations. The year 1861 marks the start of organised official meteorological observations in New Zealand and of the present New Zealand Meteorological Service, thus making the Service the oldest scientific institution in the country.

The navigators

Even before the first systematic meteorological observations were started in 1861, a large amount of weather information had been gathered about New Zealand and its surrounding seas. This came first from the early explorers, and later from visitors, missionaries and settlers. The European navigators from Tasman onwards, recorded the day-to-day weather in their logs and journals. Published accounts of the experiences of early visitors to New Zealand's shores can have left little doubt, in the minds of those who followed, that our coasts and seas are subject to violent and not infrequent storms — coupled with alarming and rapid changes in the weather. Almost all found themselves once, and some many times, fighting desperately for survival.

Although the recording of weather at sea was a matter of routine, the instructions given to the commanders of exploring expeditions usually made specific reference to the need to report on the meteorological conditions experienced with the discovery of new land. Abel Tasman was ordered to '. . . carefully note . . . what winds blow in these regions, . . . what changes of monsoons, rains, and dry weather you observe, . . .', and encountered two

storms during his stay off the west coast of New Zealand from 13 December 1642 to 6 January 1643.

The British Admiralty's instructions to Capt. James Cook, 127 years later, made no reference to meteorological observations. However the Royal Society, which looked after the instruments for recording the transit of Venus from Tahiti (the prime purpose of the expedition), included: 'A barometer bespoke of Mr Ramsden . . . and two thermometers of Mr Bird . . .', Ramsden and Bird being two well-known instrument makers of the day. Banks said of the thermometers, that they were '. . . two of Mr Bird's after Fahrenheits scale, which seldom differ above a degree from each other and that not till they are as high as 80, in which case the medium between the two instruments is set down.' Unfortunately we are not told whereabouts in the ship the thermometers were read or how they were exposed.

After completing the transit observations at Tahiti, Cook sailed southwards and then westwards, and on Saturday 7 October 1769, sighted land in conditions of light winds and settled weather. In 176 days around the New Zealand coast in the spring and summer of 1769–70, the *Endeavour* experienced the full range of coastal weather, from a near fortnight of delightful spring conditions soon after sighting the east coast of the North Island, to five weeks of storms encountered in rounding North Cape over Christmas–New Year. Of this latter experience Cook wrote:

> I cannot help thinking but what will appear a little strange that at this season of the year we should be three weeks in getting 10 Leagues to the westward and five weeks in getting 50 Leagues for so long it is sence we pass'd C. Brett but it will hardly be credited that in the midest of summer and in the latitude of 35 such a gale of wind as we have had could have happen'd which for its strength and continuence was such as I hardly was ever in before.

The *Endeavour* was not the only vessel endangered by that succession of storms in northern New Zealand in the summer of 1769–70. On 12th December 1769 the French explorer de Surville in the *Saint Jean Baptiste* sighted land just south of Hokianga and made his way around North Cape beating against north-west to north gales, finding himself in perilious situations on a number of occasions. De Surville anchored in Doubtless Bay where once again he was in danger, when north-east gales caught him on a lee shore and anchors, cables and a dinghy were lost. As soon as possible, he sailed eastwards to South America. Monneron, a supercargo on the *Saint Jean Baptiste* commented:

> In a country so much exposed to storms as New Zealand we could

> not possibly expose ourselves by remaining there longer — to lose the only heavy anchor we had left . . .

Marion du Fresne's ill-fated expedition was on the northern coast of New Zealand in 1772 while Cook's second voyage was in preparation, and his vessels also had trouble with north-west gales in their attempt to double North Cape.

Two astronomers accompanied Cook's second expedition, William Wales in the *Resolution* and William Bayly in the *Adventure*. The instructions from the Board of Longitude to Wales included the following:

> 4. You are to note the height of one or more thermometers placed in the Air & in the Shade early in the Morning and about the hottest time of the day, and to Observe also the height of the Thermometer within the Sloop near the Watches; and to make Remarks on the Southern Lights if any should appear; and to make experiments of the Saltiness of the Sea and the degrees of Cold by letting down the Thermometer at great depths, as you may have opportunity . . .
>
> 8. Wherever you land . . . Observe the height of Barometer once at least every day . . .

The expedition was furnished with 'every instrument necessary for the undertaking of the best sort and constructed by the most aproved makers.' In addition to six thermometers and two portable barometers, there was a marine barometer by Mr Nairne, a wind gauge invented by Dr Lind of Edinburgh and made by Mr Nairne, and an apparatus for trying the heat of sea water at different depths.

On his second voyage, Cook used New Zealand as a base for his great probes into the South Pacific in search of the southern continent. The *Resolution* spent nearly seven weeks in Dusky Sound in the autumn of 1773 and three periods, of about three weeks each, in Queen Charlotte Sound in the early winter and late spring of 1773, and in the spring of 1774. This time the complete meteorological logs were published. While interesting, the instrumental observations are unfortunately of little scientific value: the thermometer screen had not been devised at that time and, although the thermometers were not exposed to the direct rays of the sun, the need to shield them from radiation and to provide adequate ventilation was not appreciated. This is seen from a comparison of the noon observations made on the *Resolution* and *Adventure*, when they were anchored together for over two weeks in Queen Charlotte Sound. The recorded temperatures on the two vessels were often very close but on several days differences of 8-9 °F were found and not in any systematic fashion. The barometer readings were

similarly unreliable. Although the average pressure difference was less than one millibar, differences of 3 to 5 millibars were not uncommon and once reached 8 millibars.

The object of Cook's third, and last, voyage was to search for a northern passage from the Pacific to the Atlantic Ocean. New Zealand simply represented a convenient place for refreshment, and nearly a fortnight was spent in Queen Charlotte Sound. The instructions issued by the Board of Longitude regarding meteorological observations were the same as for the second voyage, and the equipment was similar, except that no anemometer was taken. This instrument — a simple manometer — was insensitive in light winds and difficult to keep vertical and steady. The complete meteorological log of the third voyage was published by William Bayly in 1782.

With the publication of the accounts of Cook's voyages and the scientific results, the general character of the weather around the coasts of New Zealand was fairly well established. While the recorded temperatures were not too reliable, they were good enough to show that extremes of heat and cold were uncommon, unless that is, the seasons Cook spent in New Zealand had been exceptional.

A dozen exploring and scientific expeditions visited New Zealand in the next sixty years. All made regular meteorological observations, and the published accounts of several of the voyages included the complete logs. The first of three which deserve mention, was that of HMS *Beagle*, which spent the last ten days of 1835 at the Bay of Islands. The *Beagle*'s commander, Capt. Robert FitzRoy, was to become New Zealand's second Governor in 1843 and Superintendent of the Meteorological Department of the Board of Trade, London , in 1853. He compiled the meteorological section of the narrative of the voyage. The *Beagle*'s master was E. M. Chaffers who in 1839 was appointed to command the *Tory*, the New Zealand Company's emigrant ship. Chaffers became Wellington's first harbourmaster and compiled 'Sailing Directions' for Cook Strait, which included information on the wind of the area.

The published meteorological log of the *Beagle*'s voyage contains a novel notation for some of the information included. The strength of the wind was indicated by a number on a scale of 0 to 10, which was presumably an early version of the Beaufort scale, which in the form of a 0 to 12 scale was officially adopted by the Royal Navy in 1838. The state of the sky and the weather were also recorded in Beaufort notation, e.g. **b** = blue sky, **r** = rain, etc. The appendix to the published account of the voyage also included plates illustrating various types of clouds observed.

In 1838 a United States expedition, comprising five ships under the command of Charles Wilkes, sailed south with the object of extending knowledge of the Antarctic. Wilkes spent the first months of 1838 in the South American sector of the southern oceans and the rest of 1838 and 1839 among the islands of the South Pacific. At the end of 1838 he set off from Sydney to probe the Australia–New Zealand sector of the Antarctic, unaware of Balleney's discoveries in that area; and after returning to Sydney, three of the expeditions's ships (*Vincennes, Porpoise* and *Flying Fish*) set off at intervals for the Bay of Islands, on their way to a further two years research in the Pacific.

The most interesting part of Wilkes' account of the weather in New Zealand is the record of a probable tropical cyclone, which passed over northern New Zealand towards the end of February 1840. The site and movement of the storm were later reconstructed from observations made on several ships, and this represents the first 'synoptic analysis' made in New Zealand. It is worth quoting in full:

> These islands are in the track of severe hurricanes which occasionally pass over them, particularly the northern part near the Bay of Islands. One of these occurred during our stay; it happened on the 29th of February and the first of March 1840. For the development of this gale I am indebted to the inquiries of several gentlemen of the Expedition, who were at the Bay of Islands when it occurred, and to the kindness of the masters of the vessels who were caught in it. We have five positions where observations were made, three to the north, and two to the south of its track, viz; at the Bay of Islands, on board the Brigs, *Victoria* and *Camden*, H.B.M. Ship *Herald*, lying in the River Thames [actually in the Waitemata Harbour] and the *Flying Fish*, one of our squadron; their relative position will be better pointed out by their latitudes and longitudes which were as follows, viz.;
>
> | | | |
> |---|---|---|
> | *Camden* | 31 S | 174 07 E |
> | *Victoria* | 33 30 S | 171 50 E |
> | *Bay of Islands* | 35 17 S | 174 17 E |
> | *H.B.M. Herald* | 36 49 S | 174 43 E |
> | *Flying Fish* | 40 30 S | 178 30 E |
>
> From these positions we ascertain that the storm had a diameter of five hundred miles, from the latitude of 31° to 40° 30', south. We also observe that its track was south-southwest and that its velocity was twenty miles an hour. Its centre passed just to the southward of the Bay of Islands, at which place there was a calm of ten minutes, when the storm recommenced with equal violence from the opposite quarter;

> the trees that were prostrated at the Bay of Islands were found lying with their tops to the northward . . . It was one of the most destructive that had occurred at New Zealand, the water rising to a great height, and overflowing a part of the island which had before been thought beyond the reach of the sea.

The log of the *Herald* in Waitemata Harbour shows that the barometer readings fell from 29.5 inHg at 5 p.m. on 29 February to 28.75 inHg nine hours later; and that the wind rose from force 4 to force 12 and did not drop appreciably until midday next day. The log entry at 2 a.m., 1 March reads: 'Blowing a hurricane, the wind veering in tremendous gusts from E by N to NNE. Observed the pinnace swamp astern. Struck top gallant masts and braced the yards round.'

In 1838 a meeting of the British Association recommended that magnetic observatories be established in various localities throughout the world. This led to the setting up of a major naval expedition to the Southern Hemisphere — a four-year voyage of HMS *Erebus* and HMS *Terror*, under the command of Capt. James Clark Ross. Ross arrived at the Bay of Islands in the middle of August 1841 and stayed there for three months. A magnetic and meteorological observatory was set up on shore and Ross remarked:

> . . . as any information respecting the nature of the climate of this newly-colonised country cannot fail to be useful, and as the importance of meteorological inquiries appears hitherto to have been wholly overlooked or neglected, I may hope, by inserting here a monthly abstract of the observations made on board our ships during the three months they were at anchor in the River Kawa Kawa, to contribute in a small degree to the beginning of an inquiry, which if carried out for a few years must prove of great advantage to the settlers in the management and improvement of their farms; for everyone must be aware how intimately connected the various states of the atmosphere and the consequent changes of the weather, are with all the more important operations of the agriculturalist.

Observations of temperature, pressure, wind and weather were made hourly, and the published abstracts consisted of daily means of the observations plus the highest and lowest temperatures and pressures each day.

Ross went on to compare the climate of the Bay of Islands with that of London. From his temperature measurements (and the assumption that the mean temperature of the three spring months is approximately the same as the mean annual temperature), Ross surmised the mean would be about 59 °F at the Bay of Islands. This is about 10 °F higher than London's annual mean and is not far from reality. The total rainfall for the three months from

mid-August to mid-November was measured at 25.36 inches (644 mm) with one 24 hour fall of 5.5 inches (140 mm). Ross noted that this was more than twice the rainfall given by Dieffenbach for Wellington, for the same period. The comparable present-day thirty-year normal for Keri Keri in the Bay of Islands is only 15 inches (381 mm), so that even allowing for some question about the exposure of the rain gauge, it is evident tht Ross was in the Bay of Islands during a very wet period; but his general conclusion that the spring rainfall in the Bay of Islands is considerably higher than that of London, is certainly valid.

Acting on instructions, Ross also made some soil temperature measurements. On 18 October 1841, five pairs of self-registering (maximum and minimum) thermometers, packed in suitable vessels, were buried in the earth at depths of one, six, nine, and twelve feet, and left for twenty-five days. The mean of the one foot temperatures was 61.5 °F — and by comparison the 9 a.m. earth temperature at Keri Keri for the same months over the period 1947–1960 is about 62 °F! The mean temperature at twelve feet was 59.4 °F and the temperature of the water at the bottom of a thirty-five foot well containing 6 ft 4 inches of water at Waimate was 58.8 °F. These figures confirmed for Ross his estimate of about 59 °F for the mean annual temperature of the Bay of Islands; but he added: 'This is, however, a point of considerable importance to have determined accurately, and the observations should be continued throughout several years before this can be accomplished'.

Ross's 'Voyage of Discovery and Research' was published in 1847. In 1848 his account of the climate of the country was reprinted for the information of Otago colonists in the *Otago Journal*, although the editor omitted to draw attention to the difference in latitudes between the Bay of Islands and Otago. However by this time settlers, Government and New Zealand Company officials, and others, were beginning to accumulate experience of New Zealand and to write about weather conditions in Auckland, Wellington, Nelson and New Plymouth.

Missionaries and visitors

Before 1861, there were many individuals amongst both visitors and colonists, who had recorded weather observations. They did so because of a curiosity with the natural environment, and a desire to compare the climate with that of the northern hemisphere. In England those bodies which were encouraging immigration required information, which included details of the climate, to attract people to a new life in New Zealand; however because there was a

tendency to show the new colony in as favourable a light as possible, the delights of the climate, were sometimes exaggerated!

Between 1807 and 1840 there were also a number of popular books devoted specifically to New Zealand, written by short-term visitors, missionaries and settlers, which invariably made some reference to the weather experienced. Most of the early visitors landed in northern New Zealand, and often their stay was short. The lush vegetation and the mild conditions sometimes led to lavish praise — with frequent use of the word 'salubrious', and occasional extrapolation of Bay of Islands summer conditions to the whole country!

The Revd William Yate, a missionary in the Bay of Islands in the period 1828-30, included some extravagant touches when he wrote:

> The climate of New Zealand is decidedly temperate; neither exposed to scorching heat in summer, nor to blasting frosts in winter; though the summer is warm, and the winter cold. It is no doubt salubrious and congenial to European constitutions. Those who come here sickly are restored to health; the healthy become robust and the robust fat . . .

There were however, some more objective early accounts of the climate than this: one was given by Capt. R. A. Cruise who spent ten months in northern New Zealand in 1820. He was officer in command of a military detachment on the convict ship *Dromedary* which, after landing convicts at Sydney, came to New Zealand for a cargo of spars. His book included a log of temperatures and weather conditions for each day of the visit, but no explanations are given of the time of day at which the observations were made, or of the exposure of the thermometers. The weather log shows the well-known alterations of fine with wet or stormy periods, associated with the eastward moving anti-cyclones and intervening troughs of low pressure. Cruise also gave a vivid description of the typical north-easterly storms of the far north.

All writers of this period commenting on the climate and vegetation of northern New Zealand, agreed that the natural conditions were ideal for European settlers,in spite of the storms sometimes experienced. The American artist and traveller Augustus Earle, who spent nearly nine months in the Bay of Islands and Hokianga areas, from the spring of 1817 to autumn of 1819, wrote:

> . . . I felt convinced that, if it were the object of our Government to form a new colony, they could not select a more desirable spot than New Zealand. . . . We were quite free from those oppressive, feverish heats which invariably prevail in the middle of the day at Sydney, and from the pestilential winds which are the terror of the inhabitants of New South Wales; nor were we subject to those long droughts, which are often the ruin of the Australian farmer.

Sporadic weather observations, 1840–60

With a large increase in the numbers of European settlers arriving in New Zealand from 1840 onwards, there was growing interest in recording the day-to-day weather, including instrumental observations of temperature, pressure and rainfall. The New Zealand Company, the military forces, and some individual settlers, made systematic observations over varying periods of time. These were mainly at coastal settlements, but covered the country from the Bay of Islands to Southland. In many cases the instrumental data have only limited value, because of lack of standardisation of the instruments and their exposure. The information provided was quoted in summary form in many of the descriptive publications on New Zealand appearing during this period, and formed the basis of comparisons drawn between New Zealand and European climates.

The British military forces made an important contribution to early weather observations in New Zealand. It had been suggested in 1837 that the overseas posts of the Army would be ideal places to set up observatories, tended by officers who had been especially trained in scientific observing techniques; and the idea was supported by the Royal Society, London.

The Ross expedition carried equipment and military personnel for observatories established at St. Helena and the Cape of Good Hope, and the scheme was further extended in 1851 with nineteen new observatories being set up, four in the Southern Hemisphere. Auckland was added to the list in 1853 when the Royal Engineers began meteorological observations, which they continued until 1860. The Royal Engineers arranged for the use of standardised instruments and methods of observation at all their foreign stations, and published the summarised results.

The Foot Regiments serving in New Zealand had made weather observations even earlier than the Engineers. Dr A. S. Thomson, Surgeon of the 58th Regiment of Foot in Auckland and Dr R. K. Prendergast, Principal Medical Officer of the 65th Regiment of Foot in Wellington, both compiled several years meteorological observations.

In 1856, annual publication of the 'Statistics of New Zealand' commenced, containing summaries of meteorological observations, with the first few numbers including many of the previously unpublished observations back to 1844. The object of collecting this data is given in the 1858 publication by the Registrar General, J. B. Bennett: he said that the meteorological statistics should be extended

> . . . both with a view to presenting such contributions as this country can offer to Meteorological Science generally, and in order to fortify

> by the accumulation of authenticated results of actual observations the prevalent belief in the excellence and salubrity of the climate of New Zealand.

The first collection of the scattered climatic data was due to the efforts of Thomson. He wrote in the first volume of 'Statistics of New Zealand' that although New Zealand was famous for its climate, there had been few careful meteorological observers. He made a plea for observations from places away from the coast 'so that intending emigrants, and others, may be able to judge of the inland seasons of the country from numerial data in place of verbal descriptions.' Thomson spent eleven years in New Zealand and his sympathetic curiosity about all aspects of the natural environment and the original people of the country is shown in his book 'The Story of New Zealand' published in 1859.

Early in his stay in New Zealand, Thomson investigated the influence of the climate of Auckland on the incidence of disease. He compared the hospital admissions and deaths of troops in New Zealand with those in England, and found that in 1848 there were in Auckland 674 hospital admissions per 1000 soldiers, while in Britain the figure was 921. Deaths from sickness were 11 per 1000 per year in New Zealand and 15 in Britain, and the results were further broken down into various kinds of medical disorders for comparison purposes.

Thomson also wrote on the suitability of New Zealand as a residence for Europeans who had lost their health in India, China, and the warmer parts of Australia. In his writings on the medical advantages of the New Zealand climate, he was no uncritical publicist. He wrote:

> New Zealand has been rendered famous by its climate, but like other things in this world, the climate has been injured by injudicious praise. It has been styled delightful and pleasant, terms which convey the idea of an atmosphere rarely disturbed by winds and rain, whereas there are few countries on the globe where wind and rain are so frequent and so uncertain; they are, indeed, for pleasure seekers, the two great faults of the climate.

The chapter which follows the above extract is an admirable summary, which would have given any intending emigrant a fair and reasoned account of our climate.

Another account was produced by Capt. Byron Drury of HMS *Pandora*, which spent four years in surveying duties on the New Zealand coast. This 1857 account incorporated a number of land-based observations, as well as those from the ship's own log. It is a factual statement which is astray only

in the explanation of the Canterbury nor'west föhn wind, which Drury ascribed in origin to the interior of Australia.

In the 1860 volume of the 'Statistics of New Zealand' the Registrar General commented on the meteorological appendix being much fuller than previously, and while an increase was still considered desirable in the number of reporting places, said that: '. . . enough is given here to support the judgement as to the salubrity and general excellence of the climate of New Zealand which has been repeatedly pronounced by competent observers.'

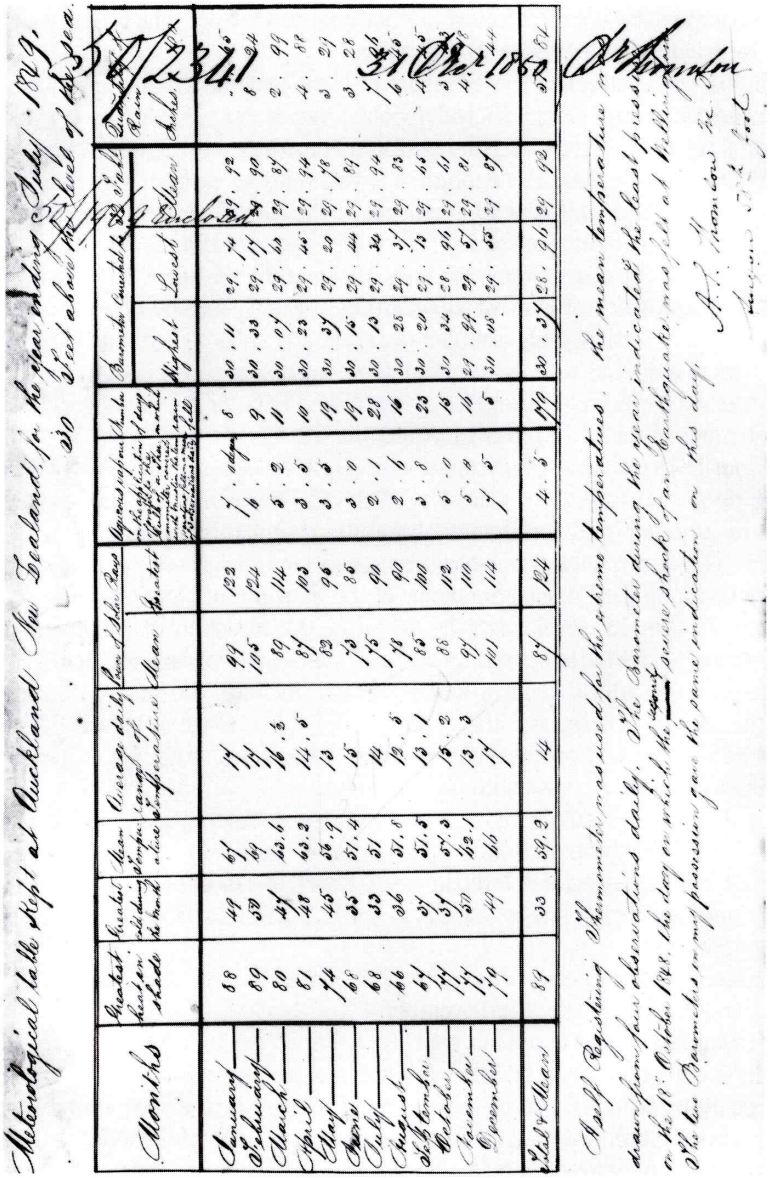
Except for the observations made in Auckland by the Royal Engineers (who had a long history of interest in scientific matters), and by other regiments elsewhere, practically all weather observations collected at this time were by enthusiastic individuals or under the auspices of those bodies who were sponsoring immigration. A list of the published data for the period, and where they may be found is given in Appendix II.

From 1848 onwards, suggestions were made for climatic data to be recorded and published under Provincial or General Government responsibility, to ensure standard and continuous observations, but this was not started until 1861. The first steps towards organising regular, official weather observations were taken by the Colonial Secretary of the Province of New Munster, Alfred Dommett. On 15 April 1848, he wrote at the direction of the Lieutenant Governor, to the harbourmasters at Wellington and Nelson, instructing them to produce quarterly reports which were to include 'the general character of the weather there, and the ordinary objects of Meteorological Science.' There is no record of the response from Wellington, but Capt. Carkeek of Nelson was not enthusiastic:

> I have no instruments for meteorological observations, and if I had, I certainly have no time to spare from my numerous duties to use them. I have directed the Pilot to keep a sort of Harbour log of the winds and weather, a copy of which for a portion of a quarter I enclose herewith.

The log for June 1848 was kept by pilot James Stirling and gave a description of each day's wind and weather.

In October 1849, Thomson sent the Colonial Secretary a meteorological table and report based on the observations he had made during the year ended July 1849. He also included annual figures for the year ended March 1849 from Staff Assistant Surgeon Robertson, Bay of Islands, and from Surgeon Prendergast, 65th Regiment, Wellington. From these statistics he compared the climate of the North Island of New Zealand with that of England, and attributed the small number of cases of pulmonary consump-



(National Archives of N.Z.)

Summary by Dr A.S. Thomson, Surgeon 58th Foot, of 12 months observations of Auckland's climate for 1848–49. This was part of a MS comparing the climates of London and New Zealand.

tion among the military forces in the North Island to the favourable climate.

The suggestion for an extended network of meteorological stations came from Arthur Ormsby, a civil engineer. On 26 December 1856 he wrote to the superintendent, New Plymouth:

> . . . I beg leave. . . to submit to your Honour the vast good which may be derived from a well kept Meteorological Register and tide table at each port where any Govt. officer is stationed, particularly a collector of customs or Resident Magistrate . . . I could not advise that any officers should be especially appointed to make these observations at each port, but I have no hesitation in saying that the officers of customs or magistrates could, without the least interference with their other duties, keep these registers if provided with the needful instruments and printed forms.

This was sent on to the Colonial Secretary's office and William Gisborne, the Under-Secretary, commented on 10 January 1857 that 'to enable the collectors or other officers at the several ports to keep Meteorological Registers and Tide Tables a sufficient number of necesssary instruments and forms of Registers be obtained.' He also emphasised the need for keeping the observing practices the same as those used in Great Britain.

Nothing further happened for two years, when Col. Mould of the Royal Engineers Auckland, at the request of the Under-Secretary, produced a detailed proposal for a network of stations throughout the Colony to record the climate. Mould enclosed a copy of the form used by the Royal Engineers and a list of the necessary instruments; he also pointed out that certain books and tables of corrections would be needed, but that the corrections of the original observations should be applied at 'the seat of Government by some qualified person appointed for the purpose'.

Ten stations were proposed: Bay of Islands or Mongonui, Auckland, New Plymouth, Nelson, Wellington, some inland post in the neighbourhood of Taupo, Lyttelton, some inland post at the foot of the Southern Alps, Dunedin, and some place on the West Coast. There is a note added to Mould's memorandum, that as long as the Royal Engineers remained in Auckland a Government station would not be required there.

The recommendations were approved by E. W. Stafford, the Colonial Secretary, and an order for the purchase of the instruments and other material sent to the Crown Colonies Agent-General in London.

Distribution of the instruments

By July 1860, fourteen cases of instruments had arrived in Auckland and were stored in the Queen's Warehouse. Mould was asked to inspect them:

he did this in a cursory fashion, not unpacking all boxs, and on being instructed by the Colonial Secretary's office to pack six sets for distribution, had to report on 18 August 1860 that he had found all the barometers broken. A 'Board of Enquiry' — set up to examine the barometers, and to recommend what should be done — found that they had been improperly packed and should be returned to the makers for repair. The New Zealand agent in London was unable to persuade the makers to accept liability and repair the instruments at no cost, and eventually sent them to the firm of Negretti and Zambra. Nearly a year later the replacement barometers arrived in Auckland, this time in good order.

It is during this episode that Dr Charles Knight, who as Auditor General was a member of the Board of Enquiry, first appears in the history of New Zealand meteorology. Knight had served with Sir George Grey in the colonial administration in South Australia and was brought by him to New Zealand when Grey became Governor in 1845. Trained in medicine at Guy's Hospital, London, Knight had wide scientific interests being especially well known as a botanist. Although his main duties for the Government were in the fields of finance and administration, his versatility was an asset to the new colony.

Knight was put in charge of the distribution of instrument sets to the Provinces. A circular letter from William Fox, the Colonial Secretary, was sent to the Superintendents of each of the Provinces in August 1861. It was accompanied by detailed instructions written by Knight, on the care and use of the thermometers and barometer, together with plans for the construction of the observatories.

The Provincial Governments were required to find appropriate persons to take charge of the instruments and to send periodical returns of the observations 'to an Officer of the General Government at Head Quarters for the purpose of making the necessary calculations and tabulating them in convenient forms for Statistical Publications.' Knight was named as the officer — or as the minute said 'Dr Knight has kindly consented to take the trouble of fulfilling, which he is most competent to do, the duties of such an officer . . .'

Between 13 September and mid-October 1861, nine sets of instruments were sent out — to New Plymouth, Napier, Wellington, Nelson, Picton, Lyttelton (from where Julius von Haast was directed to collect them and bring them safely to Christchurch), Dunedin and Christchurch. One set was kept in Auckland for Knight's own use and it was assumed that the Royal Engineers' observations would continue. Knight also reported that he would need to erect wind and rain gauges in Auckland before he could write the necessary instructions, and was granted £20 for the purpose.

For a while there was a flurry of letters from the Provinces on the problems of housing the intruments and finding suitable observers. However in spite of all the apparent activity, few regular records of the observations were received in Auckland, and by February 1863 New Plymouth was the only station furnishing returns. In October 1862 the Colonial Secretary's office gave Knight approval to instruct the officers in charge of the meteorological stations to publish statements of each week's observations in their local papers. Initially there were a number of excuses for non-compliance with the directive: the superintendent at Napier wrote that his observer was 'rather unwilling, from the inadequate salary allowed him, to continue his services and I am unable to replace him by a competent person.' Not withstanding a certain lack of enthusiasm, by March 1863 meteorological observations were appearing in:

> *The Wellington Independent, The New Zealand Spectator, The New Zealand Advertiser, The Nelson Examiner, The Colonist Nelson, The Taranaki Herald, The Taranaki News,* and *The Daily Telegraph* (Otago).

By 1864, Knight was signing letters on meteorological matters as 'Director of Meteorological Stations', but his duties would hardly have been arduous. Some of the source documents relating to the establishment of the meteorological stations, and especially Knight's part in it, are missing — probably lost in the wreck of the steamer *White Swan* on 29 June 1862. This vessel was on a voyage from Auckland to Wellington via Napier with sixty-five passengers, including the Chief Justice, Colonial Secretary and Colonial Treasurer, Auckland members of Parliament, and some public servants — including Knight. No lives were lost when the ship went on the rocks about 17 miles south of Castlepoint, but ten cases of public documents were lost in spite of 'handsome rewards' offered for their recovery.

The first Wellington observatory was erected under the supervision of the Harbourmaster, Capt. Carkeek, towards the end of 1861, situated on a hill 30 m above sea level at the rear of the government offices. John Knowles commenced twice daily observations there on 1 February 1862, and took a wider view of the purpose of the collection of observations than just to describe the climate. In his very full Meteorological Report for 1862–63, he wrote:

> To be able eventually to do that which is now ordinarily done by the Meteorological Office of the Board of Trade in London is the object aimed at by the establishment of stations in New Zealand.

He described at length the storm warning system in Britain, and said that the same service would be provided in New Zealand when the electric telegraph became available. He also looked forward to forecasting the seasonal

weather which, he said, would not be possible until the telegraph brought 'the stations into one meteorological focus.'

Dr James Hector

The Geological Survey Office in Dunedin had began to make weather observations in 1862, under the direction of Dr James Hector with R. B. Gore as meteorological observer. Hector was appointed geologist to the Provincial Government of Otago in 1861, taking up his post the following year, and by 1863 the Survey was publishing monthly tables of thrice daily weather observations — and for eighteen months even made hourly observations for the daylight and evening hours.

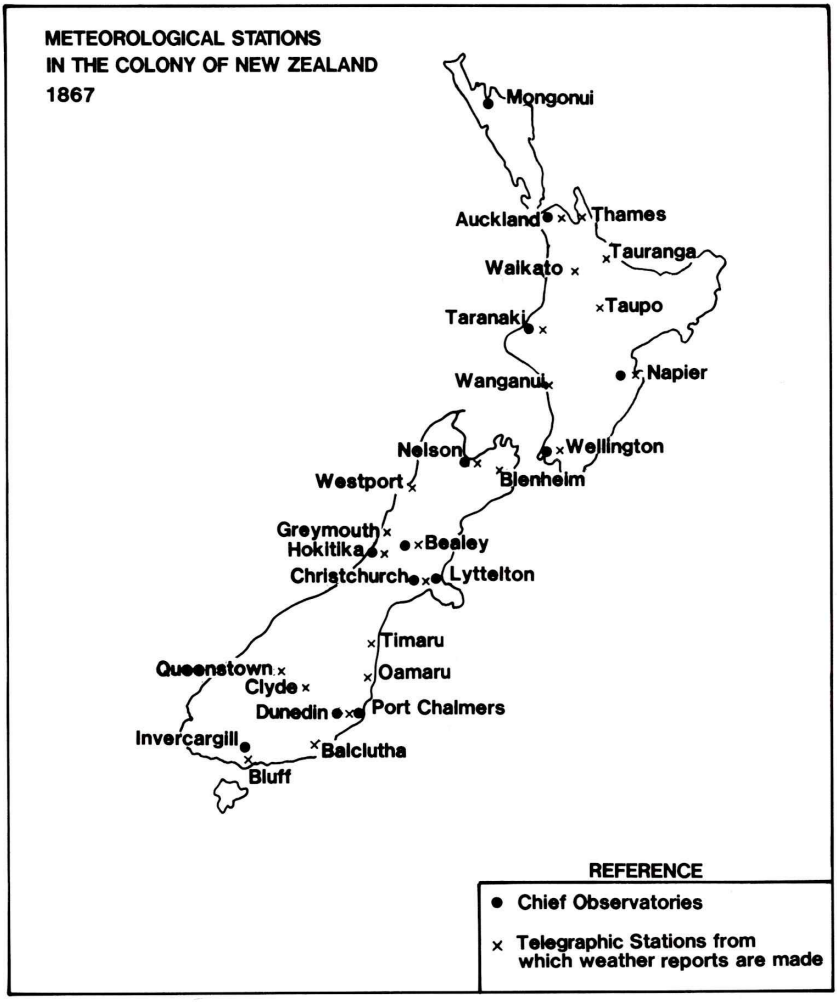
When writing to Knight requesting replacement instruments in August 1865, Gore remarked that he had been making observations for the Government using Hector's private instruments. Knight's reply made quite plain the basis on which the whole scheme had been set up:

> . . . it is to be understood that the appointment of the meteorologist in each Province belongs to the Provincial authorities and that the work is strictly Provincial work; and the only duty the General Government has undertaken is to supply the first set of instruments; to give such direction as to their use as may be necessary and to collect the observations for the purpose of publication in the 'Statistics of the Colony'.

Knight further remarked that his removal to Wellington, with the change of the seat of Government from Auckland, would give him more time for meteorological enquiries. However far from devoting more time, he was soon able to shed his meteorological duties altogether.

In 1865 Hector moved to Wellington to take charge of the newly formed Geological Survey with its headquarters in the Colonial Museum, which also housed the Colonial Laboratory. Gore who accompanied Hector, acted as meteorological statist along with other duties. Later that year, the Government set up a Commission under Knight to investigate the Geological Survey, and the organisation of science in the Colony. Its recommendation led to the New Zealand Institute Act of 1867, which provided for the establishment of a federal and scientific body, which was to comprise a public museum, laboratory and library. The chief object was 'to provide guidance and aid for the people of New Zealand in subduing and replenishing the earth'. Hector was appointed Manager of the Institute, together with his Geological Survey appointment, and another of his appointments was 'Director of Meteorological Stations and Officers in charge of Stations in the various Provinces'.

Gradually scientific effort in New Zealand became centralised under his control. By 1875 his departmental responsibilities had grown considerably



Meteorological stations 1867. Local weather was recorded at 9 a.m. at telegraph offices, and the messages sent to all telegraph offices and displayed at ports.

and comprised the following: Colonial Museum, Geological Survey, Colonial Laboratory, Inspection of Weights and Measures, Collection of Meteorological Statistics, Time Ball Observatory, New Zealand Institute, and the Botanic Garden. Meteorology was thus only a very small part of Hector's interests, and one he said later had been imposed on him. However this may well be an overstatement — even before his official appointment he had corresponded with the Colonial Secretary's office on meteorological matters.

On 26 October 1866 Hector was instructed to inspect and report on all the Government meteorological observatories. He replied on 5 November 1866:

> I may be able to visit with a view to the transference of their superintendence to the Geological Department . . . the required report will be furnished as soon as possible, until my return to Wellington I recommend that the present arrangement be continued.

In the same year he also took up with the Colonial Secretary a scheme for telegraphing weather reports daily to assist 'shipmasters in navigating the coast from Port to Port'. These weather reports were to be simple observations taken by harbourmasters, customs officers, or telegraph clerks, but Hector was careful to draw a distinction between this simple type of observation, to be used for practical purposes, and the observations made for the scientific study of climate.

> I think it would not be advisable to mix up these *Weather Observations* with the proper *Meteorological Observations* which are taken at the various Stations throughout the Colony, though in some cases it might be convenient to have information supplied to the Telegraph Office by the Government Meteorological Observer [Hector's emphasis].

The proposal to use the telegraph service for sending shipping news and the state of the weather to the various ports in the country, was agreed to by Parliament in October 1866. The Electric Telegraph Act of 1865 gave the General Government control of the telegraph system, whose first line had been opened by a private company between Lyttelton and Christchurch three years previously.

With Hector's appointment in 1867 as Director of Meteorological Stations, Knight's Audit Office handed over the instruments and the records. A memorandum to Hector from James Davis of the Audit Office during the transfer, shows that there had previously been some difficulty in getting observers to follow instructions. A list of the stations under Knight's control was given, together with the names of the 'gentlemen in charge', whom it is said were '*supposed* to take their instructions from the Director of Meteorological Stations' [Davis' emphasis].

Hector had firm views on the number of meteorological stations needed in New Zealand, and he unsuccessfully recommended his ideas to the Colonial Secretary in June 1867. He considered that four fully equipped stations with paid observers would be enough to determine in broad outline the climate of the country, but they could be supplemented with twenty lesser stations equipped with self-registering instruments. These recommendations, which were repeated with some variations over the years, were not accepted until the economic hard times of 1880 brought a reduction in government expenditure.

By 1869 the meteorological stations, observers, and the salaries paid were:

Wellington	R. B. Gore	£40	Southland	C. Rous Marten	£20
Mongonui	Henry Grover	£20	Napier	H. Knight	£20
Auckland	Thos Kirk	£50	Nelson	Henry Clouston	£25
Taranaki	Wm Northcroft	£20	Dunedin	Henry Skey	£40
Christchurch	R. Mainwaring	£40	Hokitika	John Rochfort	£50
Bealey	J. M. Munce	£20			

The differences in the amounts paid for similar duties, and the opportunities Hector took to reduce the salaries on changes of observer, caused some resentment. In 1870 the newly appointed observer at Hokitika, John Browning wrote to Hector complaining that his predecessor had received £50, while he was offered only £20. Hector's recommendation to the Colonial Secretary was that there be no increase given, for he intended to reduce all observers to the same rate, and if Browning would not accept the £20 they would get someone else. Browning accepted.

The same problem arose in Auckland when Thomas Kirk the observer, who was also Curator and Secretary of the Auckland Institute and Museum, resigned in 1873. The opportunity was taken to reduce to £20 a year the salary of his successor as meteorological observer, Elwin B. Dickson. The letterbooks for the period of Dickson's service (1874—82) have survived, and give an interesting picture of one meteorological observer of the time.

Dickson was well educated and enterprising, with a keen interest in meteorology, corresponding with meteorologists in Australia, Britain, and Europe, and writing to the latter in both French and German. He wrote articles on the weather for the *Southern Cross* newspaper, afterwards asking Hector's permission. Presumably this was given, for he later sent Hector a copy of an article he had published in the *New Zealand Herald*, about an 1880 meteorological conference that Hector had attended in Melbourne. He trusted that 'neither yourself or Mr Gore will find anything in it to which you can take exception: nor do I think that the subject is one of a nature

to preclude an officer of the Department availing himself of the medium of the Press.'

Dickson tried unsuccessfully a number of times to interest Hector in a new instrument for the automatic recording of sunshine, and did not agree with Hector's ruling that ozone observations should cease because the results obtained showed little variation over New Zealand.

By firm but respectful lobbying, Dickson had his salary raised to £35. While meteorological observer he was also Secretary of the Acclimatisation Society, and Clerk of the Native Land Court. This latter position obliged him to spend more and more time away from Auckland, and he arranged for a 'young gentleman" to make the observations while he retained the job of recording and tabulating the results. This was an unofficial arrangement, for which he asked Hector to obtain the Colonial Secretary's approval; as Dickson relinquished his position as meteorological observer about this time, it seems probable that approval was not forthcoming. He appears in the records for the last time in 1891, writing to Hector for confirmation of his dates of service as observer, so that he could make a claim against the Audit Department for compensation — the outcome is not known.

2

Storm warnings and the Marine Department

Hector's 1866 recommendations to the Colonial Secretary on the display of weather reports at the various telegraph offices around the country, were implemented by Dr Charles Lemon, General Manager of the Telegraphic Department. By 1869, local weather was recorded at 9 a.m. on a standard form at twenty-six telegraph offices, and the message distributed by telegraph to all offices and displayed at ports. The scheme ran for a number of years but the main users, harbourmasters and seamen, became dissatisfied with the standard of the service provided. Reports from the telegraph offices were said to have been not entirely reliable 'mainly . . . in consequence of the telegraph clerks being unable to spare sufficient time from their ordinary duties to make the requisite observations.'

In 1874 the Secretary of Customs, who was responsible for the Marine Department, gave details of plans to revive the scheme. The Marine Department proposed that weather information at all ports be provided by the harbourmasters, leaving a few inland stations with the Telegraphic Department. The information received was to be 'carefully recorded and studied, with a view of eventually establishing a system of storm signals such as are in use in the United Kingdom and other maritime countries.'

Commander R. A. Edwin RN (retd) was put in charge of this experimental storm warning scheme, having been appointed in 1871 to the Marine Department as an examiner of masters and mates in seamanship and navigation. With his new appointment Capt. Edwin thus became New Zealand's official weather forecaster, and he carried out those duties almost unaided until his retirement in 1908.

Born in London in 1839, he entered the Navy as a cadet in 1853, and was present at the bombardment of Odessa and Sebastapol in the Crimean War, being wounded at Sebastapol in 1854. He also served on the China station with the Navy, and during the Maori Land Wars was on HMS *Elk* in the Pacific, retiring from the Navy in 1871.

Edwin began his experimental storm warnings in May 1874 from an office

in the Custom House, Wellington, next door to the telegraph office. By the end of the year daily reports were being received from seventeen stations:

Auckland	Castlepoint	Timaru
Manukau Heads	Wellington	Oamaru
Thames	Hokitika	Port Chalmers
Coromandel	Westport	Bluff
Taupo	Bealey	Queenstown
Opunake	Lyttelton	

In spite of barometer errors, Edwin considered that his experimental warnings had in many instances been correct. He claimed that when standard barometers were issued to his reporting stations 'public intimation of approaching gales may be made by signal with nearly as much success (viz. about 80 per cent) as is now the case in older and more populous countries.'

In 1875 he sent circulars to the harbourmasters to get their assessment of his trials. Except for the Auckland harbourmaster, who replied that not one in twenty of the warnings was correct, the other estimates ranged from '50 per cent useful' to 'in almost every case correct'. This was encouragement enough for Edwin to carry on with the scheme. Official support continued, with the cost of weather telegrams being £800 for the year 1875-76. Mercury barometers to the value of £470 were received from England as replacements for the aneroids. One very strong reason for persisting with a storm warning system, was the number of shipwrecks on the New Zealand coast at that time. In the period 1874–77 there were on average about twenty-five vessels totally wrecked each year, with an annual total tonnage of about 3500 tons.

Suggestions on ways to improve the service were sought in Britain. William Seed, Secretary for Marine, visited England in 1875 and used the opportunity to consult Capt. Toynbee, the Marine Superintendent of the London Meteorological Office. Toynbee recommended that Seed write to Charles Meldrum, the Director of the observatory at Mauritius, an expert on 'weather telegraphy'.

Meldrum's reply contained an account of the tropical and extra-tropical storms affecting Mauritius, and by analogy the storms he would expect to affect New Zealand. He thought that weather reports from Australia would give one to three days warning in New Zealand of the approach of storms from the west.

It was found that the cost of weather reports by cable from Australia would be about £450 a year, despite attempts by the Marine Department to persuade the Telegraph Cable Co. to reduce the charges. As it was, the cost of the Weather Signal Department had risen from £305 in 1874-75 to £1163 in

1876-77. The prospect of further expenditure on more telegraph and cable reports, together with Edwin's requests for an assistant, caused Parliament to review the whole project to ascertain whether it was really necessary. A select committee was set up 'to enquire into the efficiency of and the necessity for the Weather Reporting and Storm Signalling Department.'

The committee reported back on 24 October 1877. It found that the storm warnings were of value, but could not decide whether the advantages obtained from the warning were sufficient to justify permanent expenditure. In this dilemma it recommended that the Department should continue for another year, pending further information on its activities. The committee also made recommendations on the priorities to be given to weather telegrams, the making of weather observations at ports and lighthouses, and public display of reports and forecasts at all ports.

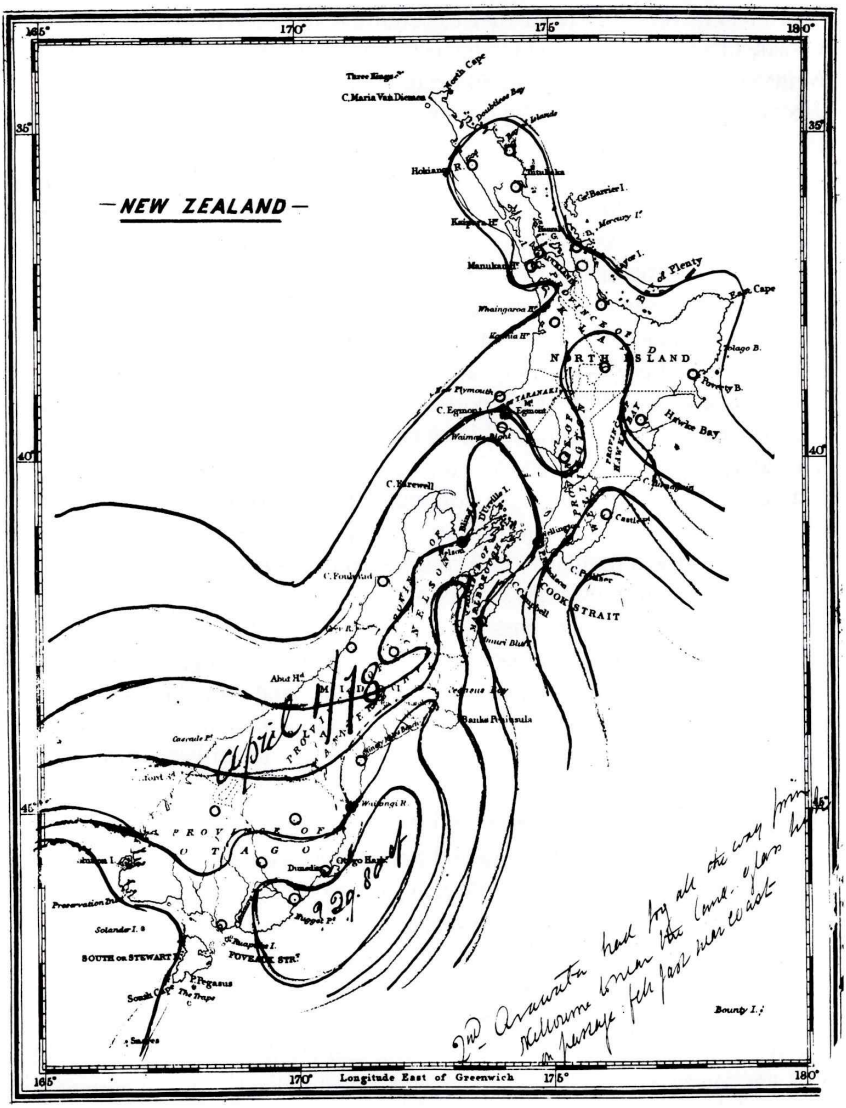
Edwin was able to continue his storm warnings, and obtained his assistant the following year. However, in the next annual report he expressed regret that the recommendations of the Committee had not been fully implemented. In the event, there was no further review and the experimental storm warnings became a regular daily forecast system. The forecasts were published in the Wellington evening papers and were 'on more than one occasion favourably noticed by the press.'

So the two meteorological organisations, the Meteorological Department with its climatological stations under Hector, and the Weather Signal Department under Edwin in the Marine Department, continued on in their independent ways — but this state of affairs was not to last much longer.

Moves towards integration

On 18 September 1879 the Colonial Secretary received an invitation from the Colonial Secretary's Office, Sydney, for New Zealand to participate in a meteorological conference in Australia. This was the result of a suggestion by the New South Wales Government Astronomer, who had 'represented the desirableness of a meeting of scientific men nominated by the Governments of the Australasian Colonies to consider what means should be adopted to improve the system of inter-colonial weather signals.' Hector, who at the time was representing New Zealand as the Executive Commissioner at the Sydney Exhibition, was instructed to attend. While some thought had been given in the Colonial Secretary's Office in Wellington to sending Edwin as well as Hector, the letter of invitation was lost in the Office for over a month before being attended to, and a note on the minute said, 'It would have been advisable also to send Capt. Edwin RN, but I fear it may now be too late.'

The conference, held in Sydney, was attended by the government



Daily weather chart for 1 April 1878 drawn by Captain Edwin.

astronomers, R. J. Ellery (Victoria), H. C. Russell (New South Wales), C. Todd (South Australia), and James Hector — described as Inspector of Meteorological Stations, New Zealand. There were no representatives from Tasmania or Queensland. All four participants were eminent scientists, and the Australians were among the pioneers of meteorology in their country.

The matters considered were far wider than had been originally suggested, and amounted to a formulation of plans for an investigation of the meteorology of the Australia—New Zealand area. Topics discussed included the observational network, standardisation of observing methods, the exchange of information by cable and telegraph, and the establishment of stations on the highest available mountains for the study of upper winds.

Edwin did not subsequently agree with the committee's proposals for regular inter-colonial weather signals. He considered that his own arrangements for getting information from the adjacent colonies free of charge, when it was thought necessary, were quite sufficient.

The system then operating in New Zealand, of two independent organisations with some overlapping interests, was unlikely to have commended itself to Hector. It was administratively untidy, when compared with the centralised control of most other scientific activities in the Colony, so that it is not surprising that the Sydney conference proposed a reorganisation of meteorological activities in both Australia and New Zealand. This was to be achieved by making the weather observations central to all meteorological functions and by placing them under the direction of one Meteorological Department in each colony. Weather telegrams and forecasts were to depend on observations, which also formed the basis of general meteorological and climatological statistics. Trans-Tasman co-operation was to be effected by the regular exchange of weather cablegrams consisting of reports generalised from the local weather reports. In the case of New Zealand, the country was divided into five coastal districts: NE aspect, S aspect, SE aspect, NW aspect, and Cook Strait.

On his return to New Zealand Hector wrote to the Colonial Secretary pointing out the financial savings that a combination of the two meteorological departments would bring, and also reminding him of the memoranda he had written on the same subject in 1867 and 1874. His original proposals had been put forward on scientific grounds, but the prospect of financial savings now promised, carried far greater appeal to the Government, especially as the Country was in an economic depression.

In due course, Edwin was asked for his views on the conference recommendations, and gave his assessment of the amalgamation issue in a long memorandum to the Hon. Walter Mantell on 11 September 1880. Mantell

was a member of the Legislative Council, a man with wide scientific interests, and also a friend and neighbour of Hector. From the inception of the Colonial Museum, Mantell had supervised its activities during Hector's absences from Wellington and, with official sanction, had also looked after Hector's other government responsibilities.

Edwin's views are summarised in the following extract from his memorandum:

> The circumstances in which I am placed compel me to state plainly the difference between Meteorology and Weather Forecast (*sic*):
> Meteorology is a subject requiring trained observers, exact registration of instruments, and laborious calculation for the purpose of obtaining averages or means of pressure, temperature etc which its advocates hope will one day become of value for the prediction of seasons and climatic changes but which have not yet been found reliable for the purpose expected of them, even in countries like Great Britain where observations have been carried out carefully for more than fifty years.
> Weather forecast; as far as N.Z. is concerned, requires no special training of the observer but demands that the officer who forecasts shall be able to distribute his forecast with despatch and his labours are an immediate result, value in this case is immediately received: in fact it is a cash transaction; for a daily value is given for a daily expenditure whereas in the case of meteorological data the true value has yet to be seen.

Ever the practical man, he followed up this broadside by quoting appreciative remarks on his weather forecasting from letters he had received, and from the newspapers. He considered the financial savings Hector saw resulting from amalgamation as unlikely, and saw the two observation networks as incompatible. The storm warning and forecast service was run as economically as it could be, and any reduction would result 'in such a loss of efficiency as to render it quite incompatible to carry on the work.'

Mantell requested comments on Edwin's memorandum from Gore, Hector's meteorological assistant. They amounted to a point by point rebuttal of Edwin's arguments, and his personal view that weather forecast and meteorology should be two branches of one department, each making use of the same basic observations.

Hector now moved quickly to reorganise his own department, submitting to the Colonial Secretary on 29 October 1880 detailed proposals with costs, for the reduction of the number of first-class climatological stations.

> The proposal now made is the same I suggested in my memo of 23

> September 1874 on the occasion of the first establishment of the Weather Department and almost the same as my original proposal when the Meteorological Department was imposed on me in 1867. The three first-class stations (Auckland, Wellington and Dunedin) suggested will give fair average records of the climate of New Zealand as they are in positions free of extremes of rainfall or drought. If any additional stations can hereafter be afforded they should be situated so as to give the extreme forms of climate experienced in New Zealand such as Taranaki and Napier in the North Island and Hokitika and Christchurch in the South.

By 1 February 1881 the main climatological stations (first-class stations) had been closed except for Auckland, Wellington and Dunedin, and it was proposed that the instruments from the closed stations (Mongonui, New Plymouth, Napier, Wanganui, Nelson, Bealey, Hokitika, Queenstown, and Southland) be handed over to the Telegraph Department, and the observations used for weather signalling. Lincoln Agricultural College agreed to take over the Christchurch observations.

Hector also proposed that if raingauges and thermometers were issued to the telegraph stations which supplied information to Capt. Edwin, the results might be included in the climatological returns of second-class stations. The third-class stations, which provided rainfall and temperature observations daily, were to be run by lighthouse keepers, harbourmasters, schools and individual amateurs. This would give all the meteorological information needed in New Zealand.

His proposals were approved by the Premier, John Hall, on 5 February 1881. The Vote for the Weather Signalling Department was disallowed by Parliament and Edwin became subordinate to Hector. Immediately approval for the reorganisation had been received, Hector arranged for Gore to tour the South Island rearranging the network of stations, while he did the same for the North Island. There was now only one Meteorological Department in New Zealand.

A combined Meteorological Department

The 1880-81 Annual Report from the Meteorological Department records that 37 stations reported at 9 a.m. each day except Sunday, and that an isobaric map was constructed and a generalised report prepared for the five coastal areas. Warnings were telegraphed to any part of the coast for which dangerous winds or heavy seas were expected. This work was performed 'as efficiently as hitherto by Capt. Edwin RN.' Telegrams were exchanged between Sydney and Wellington in special code giving a summary of the

weather and 'particularly of the movement of storm centres and atmospheric disturbances.'

A spur to the implementation of the proposals for the reorganisation was a second inter-colonial meteorological conference arranged for April 1881 in Melbourne. The same people attended as in 1879, and the purpose was to report on the recommendations of the previous conference. Hector was able to show that New Zealand had implemented practically all the main recommendations.

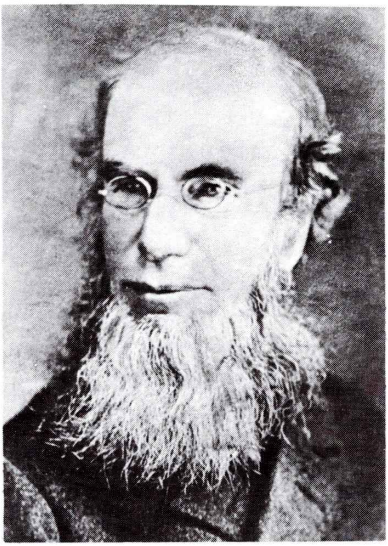
The conference considered at some length the isobaric system of analysis of the surface pressure field which was then in use in Europe and North America. Hector considered that the work done in New Zealand since 1877 showed that isobaric methods were applicable in the Australia—New Zealand region, and it was agreed that they be adopted. He submitted to the conference a code, descriptive of the commonly occurring isobaric patterns, which was suitable for the transmission of weather maps by telegraph; and for the New Zealand area identified twenty-four generalised isobaric patterns deduced from a study of charts over a three year period, as well as twenty patterns for the southern half of Australia (see Appendix III).

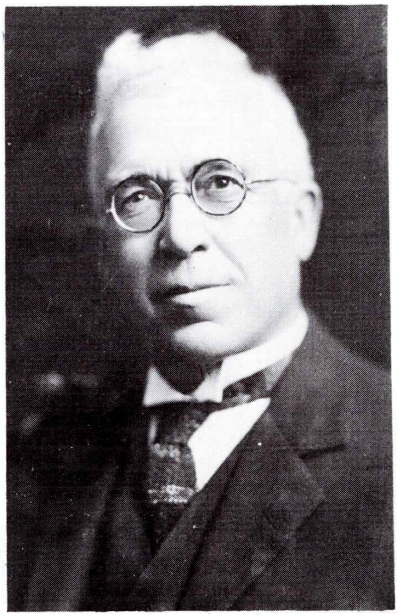
It was these generalised isobaric patterns that formed the basis for the reproduction of weather maps in the New Zealand daily papers, from December 1882. The appropriate diagram number, together with a selection of weather reports from both Australia and New Zealand, was sent to the Press Association at 4 p.m. each day for distribution to the papers. The newspapers in the four main centres held blocks of the twenty-four isobaric patterns. The reports, without the patterns, were published in most of the other papers of the Colony.

For some time after the 1881 conference, Hector and the government astronomers in Australia corresponded on the techniques of drawing isobaric patterns. The inter-colonial weather exchange began to operate on a regular basis, though with some problems of delays in the transmission of the cabled messages — Hector commented in February 1882 that most of the information was thirty-six hours old before it arrived, and that storms crossing the Tasman Sea often arrived before information could be published about them in the daily papers.

Observations from Albany, Portland, Hobart, and Sydney were exchanged for those from Auckland, Wellington, and the Bluff. According to Hector these weather messages '. . . are gradually leading to a more correct comprehension of the laws which govern the successional changes that are experienced in the temperature and moisture in these latitudes.'

No record exists of the extent to which Hector involved himself in the work





Early Directors of the Meteorological Service: (*top left*) Sir James Hector, (*top right*) Dr Charles Knight, (*bottom left*) Captain R.A. Edwin, (*bottom right*) Revd D.C. Bates.

of the Weather Signalling Department in the early 1880s, although he certainly took an interest at that time in the problems of movements of atmospheric systems; nor are his views on weather forecasting recorded.

Even though Edwin was a 'modest and amiable' man, it is understandable that he resented his subordinate role under the new restructuring which had been planned without his participation. The opposing views held by the two men on the relative importance of 'meteorology' and 'weather forecasting' were determined by their backgrounds.

Hector, as a Fellow of the Royal Society, would have known that the Society had criticised as unscientific the weather forecasts issued by FitzRoy at the Meteorological Office of the Board of Trade, London. On FitzRoy's death in 1865 the Meteorological Office was placed under the control of the Royal Society and issue of weather forecasts stopped. Storm warnings were later reinstated, but not until 1879 were daily weather charts published and a system of forecasting approved. The Royal Society considered that the principles governing the movements of storms was then better understood.

Edwin, with his maritime background, tackled the practical problem of providing storm warnings and weather forecasts using the empirical methods to hand and accumulating experience as he went. It was not a course of action to satisfy a scientific purist but on many occasions gave useful results. In the 1879 Transactions of the New Zealand Institute he published a paper on the principles of weather forecasting about which Hector commented that the methods were the same as those used in England and 'involved the acceptance of certain hypotheses not yet generally received.' However, with the restructuring complete, it appears that Hector left Edwin to provide the public weather forecasting and the storm warning service to shipping.

Divided control once more

By the twenty-sixth Annual Report of the Colonial Museum and Laboratory, 1890-91, mention of Edwin and weather signalling had ceased. The forecasting section of the Meteorological Department had been returned to the Marine Department. The reasons for the split are not known. Edwin appears by implication only in Marine Department records. There is an item of £300 for weather reporting salary in the 1890-91 expenditure. He is not mentioned again by name until the 1894 Marine Department annual report.

Once again New Zealand meteorology was under divided control, a state of affairs lasting until 1906. Hector retired in 1903, by which time his dominance in New Zealand science had been much eroded. He had few staff and although there was still a meteorological clerk and statist the work of the Meteorological Department had fallen well behind.

R.B. Gore retired in 1901 after 36 years as Hector's assistant. Besides his meteorological duties, Gore was Curator of the Colonial Museum, and Secretary to both the Geological Survey Department and the New Zealand Institute. From the mid 1880s he took over an increasingly large part of Hector's correspondence.

Hector was succeeded as Director of the Museum by Augustus Hamilton, who in August 1904 appointed as a temporary clerk the Revd D. C. Bates, on a salary of ten shillings a day. A Church of England clergyman, who had left the Church for medical reasons after service as a chaplain with the rank of Lt. Col. in the South African War, Bates was employed to collate and summarise the climatological observations. Later, in a letter to an enquirer who had written asking about employment in meteorology, Bates said that 'A boy cadet did all the work here before I started and no one worried.'

He remained on the Museum staff until the climatological and weather forecasting branches were once more combined under Edwin in 1906, when he became Edwin's assistant, under Marine Department control. Bates was to become the dominant figure in New Zealand meteorology until his retirement in 1927: he had neither a formal scientific training, nor a background in practical weather observation such as Edwin brought to the task in 1874; he did however possess energy and enthusiasm and a keen amateur interest in meteorology, and by force of circumstance had to acquire skills quickly in both climatology and weather forecasting.

A combined Service again

Because of staff shortages in the Museum the processing of the climatological records remained well in arrears. The observing stations were short of instruments, and had not been inspected for years. Hamilton on a number of occasions lobbied Sir Joseph Ward, Minister for Internal Affairs, for increased expenditure and more staff, and also sent to the Minister his views on a reorganisation of the Meteorological Department.

On 1 December 1906 the Museum finally relinquished control of meteorology, which it had exercised since 1867, and the Meteorological Department was now recombined with the Weather Reporting Department under the Marine Department. Edwin became Director of the combined Service and Bates his assistant — they were the total staff. As daily forecasts had to be prepared six days a week, the climatological records for the whole country checked and processed, and the observational network of reporting stations maintained, they faced an impossible task.

Initially the Marine Department took its new responsibilities seriously, and got approval for a modest increase in the expenditure of its Meteorological

Department. This was enough to ensure the publication of a monthly bulletin of meteorological statistics together with a description of the month's weather, and also to give an increase in the scope of the weather forecasting services.

Oamaru rain-making attempts

The Department became involved in an unusual meteorological exercise and attracted a good deal of public attention in 1907, during the affair of the Oamaru rain-making experiments. North Otago, with its south-eastwards opening valley flanked by mountains rising to 2000 metres (6500 feet), is a farming region subject to periodic long dry spells. During such a three-year period in 1890—91, a committee of farmers received a government subsidy to match locally raised money for the purpose of conducting rain-making experiments in the Oamaru district.

It was part of European folk-lore that gunfire, under 'suitable' atmospheric conditions, could produce rain, and battles were known to have taken place frequently in the rain. The Government sold explosives to the committee at cost, and the military authorities sent members of the Torpedo Corps to supervise the explosions. They took place on a 30-foot (9 m) derrick on top of a 310 m hill: there were three tests in November 1891, and after the second, heavy and extensive rain fell. The committee concluded that although the results may only have been a coincidence, the trials offered encouragement for the method to be used in future droughts.

From February 1906 to July 1907 there was only one month in the area with rainfall above average, and losses in farm production were estimated to be over a million pounds. Once again there was agitation for government funding of rain-making trials, and the Premier promised a pound for pound subsidy up to £200. A local committee was formed and the necessary money raised.

This time the Government instructed the Meteorological Department to send an observer to report on the experiments, and Bates went to Oamaru. There was intense local interest in his visit, and his comments were reported at length by the press. He made it clear that he had not come to show the farmers how to make rain, and refused to be drawn on the feasibility of the method to be used. He had been sent, he said, not as an advocate but as a scientific observer; his mission was to watch the state of the atmosphere and the 'approaching depressions', and to report to the committee running the trials.

The military provided a corporal and four men, and three series of explosions took place. The results were not encouraging: the showers which

fell were nowhere near the explosion area, and the *Oamaru Mail* — previously sympathetic — was forced to conclude:

> The artificial production of rain has now had a fair trial in this district and it can scarcely be said that the results of the experiments have been such as to encourage resort to similar methods of breaking a drought.

Bates stayed in Oamaru for twelve days. During this time he gave a public lecture on meteorology, took the Sunday services at St. Luke's Church (preaching on 'Clouds and their Spiritual Teachings')*, established four new rainfall stations, and observed and commented freely on all facets of the tests.

The newspapers in the rest of the country were largely critical of the Oamaru rain making efforts. The Wellington *Evening Post* was particularly scornful. The fact that Bates was a clergyman as well as a meteorologist also caused a number of jibes. The *Free Lance* wanted to know whether it was an act of renunciation that the 'reverend meteorological expert' went to Oamaru with dynamite and gun-cotton and left behind all the special collects and rain petitions of the Liturgy.

Bates' report to Parliament is a clear, balanced account of the experiments and was reprinted in the American *Monthly Weather Review*. He concluded that:

> These costly efforts in rain-making are regarded at present as misguided and vain by all scientific meteorologists while to their chagrin really valuable work is often neglected for want of public interest.

The message was not heeded, as further government money was again forthcoming for the same purpose in 1910; but this time the Meteorological Department was not consulted.

The end of the Edwin era

On 1 July 1908, Edwin retired at the age of 69. The only recognition of his 34 years continuous service was the comment by the Secretary for Marine in his annual report that 'during the long period that he has been in charge of this office he has been most assiduous in his duties' — but this fails to do justice to Edwin's contribution to meteorology in New Zealand.

The 19th century was necessarily a period of observation and classification in all sciences in New Zealand. In the study of weather systems, the commonly occurring isobaric patterns, their movement, deformation, and associated weather, had to be discovered. Edwin had painstakingly built up

* He might well have quoted Jeremiah 14.22: Are there any among the vanities of Gentiles that can cause rain?

this knowledge over the years and had attempted to explain the progression of weather systems affecting New Zealand in simple models which he described in a paper published in 1904. As he said in a letter to Dr Napier Shaw, Superintendent of the London Meteorological Office, 'The views I have advanced have not been hastily arrived at; and the principles stated in the pamphlet [the 1904 paper] . . . have been in daily use for the last 16 years.'

At the time of Edwin's retirement, isobaric charts were drawn daily, except for Sundays and public holidays, and forecasts of the locally expected weather were sent to sixty-two telegraph offices and eight lighthouses. A general forecast for the whole country was published in the *Evening Post*, Wellington, while other papers published local forecasts.

The forecasts sent by telegraph were for reasons of economy expressed in a special code, originally devised by Dr Lemon, General Manager of the Telegraphic Department. For example a message which read: 'Act, Boat, Used, Exact, Just, Dent, Left' meant 'Northerly, strong winds to gale, glass fall soon, tides high, seas heavy, rivers high after ten hours, weather probably warmer'. A similar type of code was used until 1935.

The climatological network consisted of 23 main stations and 220 rainfall stations. In 1892 G. J. Symons, who was in charge of the British rainfall network, wrote to Hector expressing satisfaction 'that your colony has reversed its mad policy of 1880 and now has a good batch of stations.'

The Revd Bates — director 1908-27

On Edwin's retirement Bates was appointed his successor as Director of the Meteorological Department. To cope with both the forecasting duties and the large amount of clerical work, he was given an increase in staff — a clerk and a cadet. Bates was the sole member of the staff with any meteorological experience, and carried his professional duties on alone until the appointment of a scientific assistant in 1910, when B. V. Pemberton was transferred from the Magnetic Observatory, Christchurch. This was a fortunate appointment and Pemberton was to become indispensible, carrying a large share of both the technical and administrative duties of the Department over the years.

Soon after appointment as Director, Bates began what was to be a continuing battle with officialdom, over his practice of making statements to the press on departmental and government policy, as well as on technical matters on which he was entitled to comment. In his first skirmish, the Secretary for Marine threatened 'That as frequent breaches of the regulations have been committed regarding information to the press in defiance of Regulations and Cabinet Instructions, any further breach will be visited by dismissal.'

Successive Secretaries had similar problems. During another confrontation, an exasperated Secretary ruled that even rainfall and other climatic information had to be released to the press through the Marine Department — Bates was to have no access to the press — but this soon proved an impractical arrangement and was quickly relaxed.

The Public Service system of the time was extremely rigid, and there was little freedom of action for Bates even on technical meteorological matters, many of which had to be referred to the Secretary for Marine. Two examples illustrate the point:

The Walsh brothers' flying school at Kohimarama, Auckland, was recognised by Britain as an approved training establishment for pilots to serve in the RAF during the 1914—18 War. The New Zealand Government gave practically no support and the pupil pilots paid for their own tuition. In 1918 Leo Walsh wrote to Bates asking for assistance in establishing a weather bureau at the flying boat base. An anemometer especially was wanted, but the Marine Department turned down the request because of 'the high cost of the instrument and the difficulty of procuring it.' It did however, agree that the flying school could be provided with weather forecasts on the payment of £2 a year.

Bates then suggested that the anemometer at Mt Etako wireless station in Wellington (which was to be withdrawn) could be transferred to Kohimarama. The Secretary for Marine did not agree: he thought that Albert Park in central Auckland was a more appropriate place and said

> . . . it is not considered desirable that such an instrument should be lent to private persons. It has therefore been decided to install it in the enclosure in Albert Park.

A plea from Bates on behalf of Walsh for the matter to be brought to the attention of the Minister, produced no change.

The sacrosanct nature of Government property was again illustrated in 1922, when Bates withdrew a mercury barometer from Whangarei. The instrument was thought to be broken and was sent to Professor Burbidge of the Physics Department, Auckland University College, for testing and repair. Burbidge was then allowed to borrow it for use in his experiments on 'wireless and weather'. This brought an immediate reprimand from the Secretary, quoting at length Public Service regulations on the use of Departmental property. The barometer had to be retrieved and returned to the store in Wellington.

The ingenious ways in which Bates tried to side-step the obstacles raised by a rigid system did little to endear him to the bureaucracy, and unfortunately produced only suspicion and further reaction. The Marine Department

became niggardly in approving the allocation of resources to its Meteorological Department; and attitudes hardened in the face of memoranda such as Bates wrote to the Secretary in 1920:

> My demands have been modest in the extreme and I have refrained from all agitation by which I might have forced the hand of Government to provide for the proper publication of its climatic advantages, and also ensure a weather service adequate to the needs of this Dominion.

Requests for more staff and increased facilities were rarely considered favourably. Staff numbers stabilised at five of whom only two were meteorologists. What was achieved with very limited resources was a tribute to the enthusiasm of Bates, and the stability provided by Pemberton in carrying out the routine duties. He and the clerical assistants carried out the work of the Department, during the many long absences of Bates from Wellington.

Plans for expansion of the Service

It had been expected that the introduction of wireless telegraphy would increase the number of weather observations from outside New Zealand, by enabling ships at sea to report. However the quality of the reports received in 1913 was not up to expectation, because of non-standard instruments on the ships, and the limited opportunity for personal contact by the Meteorological Department with the ships' officers making the reports. Attempts to organise ship reports for climatological purposes had been made years before this: in the late 1870s charts of the Tasman Sea, for plotting the ship's position and the weather experienced, were supplied to shipmasters trading between Australia and New Zealand, but the desired information was rarely supplied and the system fell into disuse.

In 1914 Bates went to Australia to discuss wireless weather reports from ships and the provision of maritime forecasts. A New Zealand contribution towards the maintenance of the Australian station on Macquarie Island in the Southern Ocean was also on the agenda, as daily weather reports were received in New Zealand from this station.

As a result of this meeting the New Zealand Government agreed to pay £500 a year, for not more than three years, towards the cost of the Macquarie station. Australia undertook to prepare suitable codes for the transmission of messages from ships, but before the scheme could be put into operation a war-time ban on radio broadcasts from Allied shipping was introduced.

The 1914–18 War had little impact on the work of the Meteorological

Department. After the armistice there was a conference of Empire meteorological directors in London, followed by an international meteorological conference. Bates represented New Zealand at both meetings, leaving Wellington in July 1919 and returning in January 1920.

Bates' contact with Northern Hemisphere meteorologists, and his observation of the advances that had taken place in the war years, resulted in a proposal for an extension of services in New Zealand. A surge in commercial aviation was expected, so that as well as submitting his plans to the Secretary for Marine, he sent copies to the Chief of General Staff, and Col. Bettington who was Air Force advisor to the Defence Department. The proposals included:

An addition of two professional officers,
An upgrading of the synoptic and rainfall networks with paid observers,
Four kite stations in connection with aviation (kites had for many years been used for carrying aloft meteorographs for upper temperature soundings),
One kite station for non-aviation purposes,
Four mountain stations, and
Two radio station observatories.

The initial cost was estimated as £5456 and the annual expenditure at £3620.

Considerable aviation activity took place in New Zealand in 1920. Post Office plans for aerial postal services were discussed in the press, and Bates very properly warned that an adequate meteorological service was essential to such an enterprise, otherwise 'it would, in my opinion, be very dangerous to institute regular services in this windy country.' An Air Board was set up by the Government, although the *New Zealand Times* of 23 June 1920 cynically remarked that the Aviation Board to advise Government consisted of soldiers, and Post Office, Public Works, and Lands and Survey officials — but nobody with any knowledge of aviation.

The Board convened a meeting between Professor E. Marsden, Victoria University College, Capt. L. M. Isitt, officer-in-charge of government flying machines, Sockburn, Christchurch, and the Revd Bates, to discuss aeronautical and meteorological research. However, as far as the Meteorological Department was concerned very little resulted from all this activity. By 1923 lack of Government interest and an economic slump had stopped most aviation. Bates' request to buy surplus British meteorological stores, of which large quantities were offered after the war at bargain prices, resulted in only a £250 order. His requests to take on trained meteorologists from Britain were refused. One well qualified applicant was turned down because 'the Govern-

ment does not consider the appointment essential at the present time.' The Meteorological Department received no additional staff, and the proposals for upgrading and modernising the organisation were ignored.

At about this time public radio broadcasting services were being developed, and the interest that would result from the broadcasting of weather information was early realised. The pioneer in this regard was L. W. White of Auckland Radio Services Ltd., who operated a licensed station with call sign 1YA. In August 1923 he wrote to Bates requesting weather forecasts for Dominion-wide dissemination, as his station could be heard in most places in New Zealand on one- or two-valve sets. Shortage of staff made it impossible to accede to the request. Two meteorologists were already providing public forecasts six days a week, and could not meet White's schedules. Bates however offered to provide a few trial forecasts on special occasions, with a view to making arrangements with Government for facilities to provide a regular service, but this was not to happen until 1928.

The depression of the early 1920s brought cuts in government expenditure and increases in the charges for government services. The most serious for the Meteorological Department was a rise in Post Office charges which caused a reduction in the number of weather reports that could be afforded. Bates' response was to attack Marine Department policy, in a draft on his Department's activities submitted for inclusion in the annual report to Parliament. He alleged that only shipping interests were considered by the Marine Department and that the meteorological reporting and forecasting services were in a crisis situation. While this was undoubtedly true, his remarks did not appear in the Department's annual report.

These years saw an expansion in public works in New Zealand with increases in road, rail, and hydro-electric power generation construction; and the need for a detailed knowledge of the country's rainfall led to an uncoordinated increase in the number of rainfall stations. The Meteorological Department by the mid 1920s had about 400 voluntary observers measuring daily rainfall, while the Public Works also had its own network of stations. No central authority was responsible for hydrology and in 1922 a government committee, of which Marsden was a member, was appointed to inquire into the subject and the lack of co-ordination in the national effort. While the problem was recognised, no remedies were introduced; but the presence of Marsden on the committee was significant in light of the part he was to play later in the shaping of the New Zealand Meteorological Service.

From Marine Department to DSIR

In 1924 the Secretary for Marine, G. C. Godfrey, made an unsuccessful

attempt to have the Meteorological Service transferred elsewhere and pointed out to his Minister that in 1923–24 the Meteorological Department had cost £5476 while the revenue was just over £5. The main work of the Branch — the issuing of weather forecasts and the collection and publication of climatic data — he said, was of interest to other government departments besides Marine, whose main responsibility was to shipping. Farming, forestry, public works, and lands interests also derived benefits, and should assist in paying.

Godfrey recommended successfully to his Minister that discussions should be held with the Postal Department with a view to it taking over the Meteorological Department. The reason advanced was that a large part of the expenditure on meteorology was to the Post Office, which had offices in all parts of the country. Staff at these offices could act as meteorological observers, who would 'be under direct control and discipline and would be more satisfactory and dependable than the present honorary observers who are really under no control and whom we are unable to discipline.' However the Postal Department was not interested in discussing the proposal.

The wish for separation was not all on one side. In 1923 Bates requested the Secretary for Marine to initiate discussions for a transfer of the Meteorological Department to the Department of Internal Affairs where it had been in 1906, but this was not agreed to.

Many years before, the first steps towards the co-ordination and more adequate government support of science in New Zealand had been taken, when a Board of Science and Art was set up by Act of Parliament in 1913. Among its various committees was one on meteorology, which in 1924 heard evidence on the minimal co-ordination between the various government departments making meteorological observations. The Secretary for Marine became aware that the committee had been unable to make progress in suggesting a reorganisation of the national work in meteorology, climatology, and hydrology; and suggested that the Board should be asked specifically to investigate the Meteorological Branch of the Marine Department, with a view to placing its work 'on an efficient, accurate, and valuable basis'. This was agreed to and a committee consisting of R. W. Holmes and F. W. Furkert of the Public Works Department, Dr E. Marsden (then of the Education Department), and G. P. Morgan, was set up. It addressed itself to the fundamental question, 'Why should there be a Meteorological Department at all?'

The report of this committee, received by the Board in January 1925, gave a clear analysis of the necessity for a national meteorological service which was not just a weather forecasting branch of the Marine Department. Indeed,

it considered that weather forecasting should be less than 50 per cent of the activities of a meteorological service. The committee stressed the need for meteorological research and its applications to hydrology and agriculture, and pointed out the impossibility of undertaking research in the present understaffed organisation. The committee's suggestion to overcome the problem of control by non-technical administrators, was the appointment of an honorary advisory board which included representatives of the universities to advise the Government on the work of the Meteorological Department. Other recommendations referred to the compilation and publication of all meteorological information that had been collected in New Zealand, the upgrading and possible reduction in the number of weather reporting stations, stream gauging, and the appointment of professional assistants for research in hydrology and in agricultural meteorology. The report saw no reason to shift the Meteorological Department from the administrative control of the Marine Department.

This arrangement was not what the Marine Department had hoped for, and in a minute to his Minister the Secretary wrote:

> . . . I frankly confess I should be glad to get rid of it [the Meteorological Department] but if, on the other hand, the Government is prepared to expand its operations to the extent recommended by the Committee and so create a service of real economic value to the public, then I am perfectly willing, with the assistance of the Committee or Board proposed, and providing properly qualified staff is made available, to undertake the work of reorganisation.

On 5 August 1926 there was a long discussion on the Meteorological Department and the standard of service it provided, during the debate in Parliament on the Marine Department estimates. The Leader of the Opposition, H. E. Holland, reported that over the nine years from 1917–18 to 1925–26 a total of £2480 had been voted for the purchase of meteorological instruments. Only £866 had been spent, and he accused the Government of failing to provide adequate resources to enable the Meteorological Department to function efficiently, a criticism which was fully justified. Frequent and urgent pleas from Bates for approval to buy instruments, to keep his observing networks operating, were ignored; and the network had run down because of lack of regular inspection, and non-replacement of broken instruments. For years, approval had been given for the purchase of only some of the instruments requested, and the financial allocation for this item was invariably underspent.

The ideas of centralised control and co-ordination in Government science gathered momentum slowly. In 1925 Marsden became chairman of yet

another committee, this time set up by the Department of Internal Affairs to report on scientific and industrial research. The conclusions were similar to those which other committees had arrived at over the previous ten to fifteen years.

While the scientific institutions in New Zealand had been scrutinised thoroughly enough by this time to give the Government an adequate basis for complete reorganisation, the presence in Australia of an overseas expert was taken as an opportunity for yet another review of science. Sir Frank Heath, Secretary of the British Department of Scientific and Industrial Research, was invited by the Australian Government to report on the reorganisation of the Commonwealth Institute of Science and Industry. The New Zealand Government received United Kingdom approval for Heath to visit here after he had finished in Australia.

The Meteorological Office was reviewed, along with all other government-supported scientific organisations, and the remarks in the Heath report on meteorology are reminiscent of Marsden's previously expressed views. The report dealt with the Meteorological Office, the Geological Survey, and the Hector Observatory together. It said that the Meteorological Office, which cost nearly £5000 a year (largely expended on telegrams), needed with the other two institutions a single scientific authority to judge its claims for State support with sympathy and discernment. Heath also considered it important that the Meteorological Office should be brought into close touch with agricultural research, as well as providing services for marine, military, and air service users: it should serve all alike, but would do best if attached to none of them — but was subject to the criticism and inspiration of competent scientific judgement. It was also thought important to link up the Samoa observatory with the Dominion's Meteorological Service.

The main recommendation of the Heath Report was the establishment of the Department of Scientific and Industrial Research (DSIR). This was implemented on 31 August 1926 by the Scientific and Industrial Research Act, and Marsden was transferred from his position as Assistant Director of Education to the DSIR as its first Secretary.

The Meteorological Branch of the Marine Department came under the control of the DSIR on 1 September 1926, and a new era commenced for meteorology in New Zealand. Applications were called for the position of Director of the Meteorological Service in February 1927, and Dr Edward Kidson, a New Zealander who was then Assistant Director of the Commonwealth Bureau of Meteorology and head of its research department, was appointed. Bates who was replaced as Director, was retired, but the Government retained him as a meteorological adviser until 1933.

Bates remains a controversial figure in New Zealand meteorology. The enthusiasm and undoubted energy he brought to his responsibilities for the country's weather forecasting and climatological services were unbounded. It has to be admitted, however, that his personality was such that friction was inevitable with whoever in the Public Service had oversight of the Meteorological Department. This, combined with the tight financial restrictions of the times, led to unsympathetic treatment of reasonable proposals for modernisation and expansion. Yet in spite of the obstacles, the climatological and rainfall observing networks were doubled in his time and the public weather forecasting services expanded.

As was pointed out by the various inquiries into the Meteorological Department, progress depended on the appointment of technically trained staff. Meteorology had applications in many fields, and both diversification of interests and research were needed if the Service was to cater adequately for the national requirements.

The newly appointed Director was well qualified to provide the stimulus for expansion, while the organisational arrangements gave promise of a more understanding control than had existed previously.

3

Kidson and expansion of the Service

Edward Kidson brought to his appointment as Director of the New Zealand Meteorological Service, a sound academic training in mathematics and physics and an international reputation in meteorology. After graduating from Canterbury University College he joined the Magnetic Observatory in Christchurch in 1905, and in 1908 went as magnetic observer to the Carnegie Institution in Washington, taking part in magnetic surveys in South America and Australia, and cruises on the magnetic survey ship *Carnegie*. As part of the magnetic survey of Australia, Kidson organised and led two trans-continental expeditions — travelling mostly by camel. The first in 1912, of four months, was from Adelaide to Darwin; and the second in 1914, of five months, from Perth to Wyndham in Western Australia.*

Kidson came to meteorology through war service in 1915—19 with the meteorological services of the Royal Engineers. Recruited by Dr Napier Shaw, Director of the London Meteorological Office, he spent his war years in the Balkans Campaign, being awarded the OBE (military) and mentioned in despatches for his application of meteorology to a variety of military purposes.

In 1919 he returned to the Carnegie Institution, and was appointed observer in charge of a new observatory in Western Australia. He finally left magnetic survey work in 1921 with a shift to the Commonwealth Bureau of Meteorology, Melbourne. Because of his experience in the measurement and use of upper winds for artillery purposes, he was given control of the upper air branch of the Bureau and, in 1923, of its Research Division.

Kidson quickly interested himself in other aspects of meteorology making contributions in synoptic meteorology and weather forecasting, climatology and Antarctic meteorology. During this period he made overseas visits, took

---

* Excerpts from his journal describing day to day experiences on these journeys and a photograph of Kidson in solar topee astride his camel are to be found in the biography *Edward Kidson* by Isobel M. Kidson.

part in a solar eclipse expedition in Australia, and gained a DSc degree from New Zealand.

In 1927 he came to the New Zealand Meteorological Service with its staff of four of whom only one (Pemberton) was an experienced meteorologist, and his first year in Wellington was one of hectic activity. Not only had the routine work of the Service to be kept going, which entailed the Director taking his turn with weather forecasting duties, but the expected reorganisation needed urgent attention.

Within a few weeks of arrival in Wellington he went with Marsden to Central Otago to meet the local fruit growers, and discuss the frost fighting problem. The prospect of measures to alleviate the fruit losses from frost, led the Fruit Growers Association to request the Government to provide the necessary meteorological organisation and equipment to investigate frost fighting in the district, under the charge of a qualified officer. Later in the year a similar exercise was carried out in Hastings, and although no extra facilities were immediately made available to the Service, a start had been made in diversifying its interests. Nearly 60 years later, methods of preventing frost formation in orchards are still being investigated.

The quality of the basic observations on which the work of the Service was based was found to be far from satisfactory, and Kidson and Pemberton started a programme of inspection visits to the observing stations. According to Kidson's first annual report, there was no climatological station in New Zealand with a satisfactory long-period record.

The weather forecasting service was extended to week-ends and public holidays and forecasts were broadcast twice daily by the Radio Broadcasting Company. From 1 November 1928 there was a radio broadcast at 9 p.m. daily which, besides the forecast, gave the afternoon weather conditions at thirteen places in the Dominion as well as those at Norfolk Island, Sydney, Hobart, and the Chatham Islands. Listeners were invited to draw their own weather maps on specially printed forms. The procedures used in producing the forecasts were also revised. Kidson, in the proposals for reorganisation submitted to the Advisory Council for the DSIR, said:

> New Zealand appears to have been living for many years in a meteorological backwater. The codes used and the form of the information collected for forecasting purposes differ widely from present day international practice.

The demands of aviation

Aviation was not long in bringing demands for meteorological services, with the prospect mooted of New Zealand being included in an air link with Bri-

tain. The development of airships had led to the concept of an Empire airship route linking Britain, Canada, India, Australia and New Zealand; and a British airship mission visited the country in September 1927, to select a suitable airship mooring mast site, and prepare plans for the necessary meteorological services.

The New Zealand proposals included the installation of Dines pressure tube anemometers, and the appointment after training in England of an officer to take charge of the aeronautics division of the New Zealand Meteorological Service. However New Zealand's plans needed to be co-ordinated with those of Australia, whose Government decided against an aeronautical meteorological division, so New Zealand followed suit. Delays were experienced in England with the production of the airships for flight trials, and the crash of the airship R101 on its initial flight to India finished all hopes of an Empire airship route.

Weather forecasts were supplied within New Zealand for aeroplane flights as required. Trans-Tasman flights were proposed both in 1921 and 1924 but not attempted; however in December 1927 two New Zealanders G. Hood and F. R. Moncrieff, and an Australian I. L. Knight, approached the New Zealand Government for meteorological and other assistance for an attempt. Collaboration with the Australian Bureau and shipping in the Tasman Sea was also requested, to provide weather reports and forecasts for 24-hours ahead. Moncrieff and Hood took off from Sydney on 10 January 1928, having been given all possible meteorological information, but disappeared without trace.

Later in the year the successful Kingsford-Smith trans-Tasman flight took place. Hourly reports were organised from lighthouses, with special pilot balloon flights from Christchurch, and reports passed to the aircraft in flight. Conditions were appalling: a depression in the mid-Tasman produced heavy rain, icing, and lightning, with a flight time of 14 hrs 25 min. Both Kingsford-Smith and Ulm, the co-pilot, subsequently wrote appreciative letters to Kidson for the service provided.

In 1929 two additional professional officers were appointed to the staff, R. G. Simmers, a physics graduate from Canterbury University College, and (for a year) Andrew Thomson, previously Officer-in-Charge of the Apia Observatory. Thomson assumed control of the upper air work, and began pilot balloon observations in Wellington. These were also made by H. F. Skey of the Christchurch Magnetic Observatory, and a research grant was given to F. H. Sagar of Auckland University College to develop upper wind soundings in Auckland. Simmers was appointed as meteorologist to Mawson's British, Australian, and New Zealand Antarctic Expedition, and went to

England in July 1929 to supervise the installation of meteorological instruments on the expedition's ship *Discovery*.

Kidson took every opportunity to stress to the community, the value of the activities of the Meteorological Service, other than weather forecasting. In his 1930 annual report he says:

> Forecasting is liable to eclipse the other activities of this Branch in the eyes of the public, but its most important duty is the collection of statistics which are required for the advancement of agriculture, engineering and other pursuits.

He also began a critical inspection of the climatological records, and found that although some stations had unbroken observations back to the 1860s, site changes and faulty instruments made the records far from homogeneous, and therefore of limited value.

The international conference upset

While Kidson had expected to attend the 1929 Empire Meteorological Conference in London, as well as an International Conference in Copenhagen, the Government surprisingly decided that Bates should represent New Zealand at both those meetings. The Director of the London Meteorological Office, Sir George Simpson, saw Marsden who was in London at the time, to urge him through the New Zealand High Commissioner to seek a reversal of this decision. Marsden's own recommendation to his Minister that Kidson should attend the meeting had not been accepted. The Minister, the Hon. H. Atmore, was quoted as saying:

> It is not right to say that Mr Bates was not actively engaged in the Department since he was engaged as a record meteorologist . . . It is desirable that Mr. Kidson remain in New Zealand to obtain a knowledge of local conditions. Any information that Mr. Kidson could have obtained would be obtained by Mr. Bates and would be of ultimate value to the Department.

The affair was used by the Parliamentary Opposition to berate the Government, and *The Dominion*'s summing up was:

> The only assumption that can be made is that the appointment was a piece of favouritism in which personal considerations outweighed the interests of the Department and the Community.

In spite of all the protests there was no change in the decision, and no benefits from the conferences were derived by the Service. Marsden had done what he could, but was himself in an unhappy situation because of political interference in the affairs of the DSIR.

Kidson was bitter and despondent over the affair: the more so, when

decisions were made at Copenhagen which suited northern hemisphere countries, but not Australia and New Zealand. Australia was also unrepresented, the Director of the Commonwealth Bureau being held too near retirement to be sent. Kidson expressed his views to Sir George Simpson in London who replied:

> I have just received your letter of 13 January 1930. On reading it I cannot help feeling what a calamity it was for meteorology in Australasia, in fact to official meteorology as a whole, that you were not allowed to come to the conference last year. If you had been you would certainly not have written — 'It has been my experience that nothing said in these parts [Australasia] influences decisions at European Conferences.

A new building and the great depression

Following its transfer to Marine Department control in 1906, the Meteorological Service had been accommodated in a series of office buildings in Wellington City, being always housed as near as possible to its communication centre, the Post and Telegraph Office. Until 1910 it was in the Post Office building itself, but its next two moves — to the Royal Exchange Buildings in 1919, and the Government Life Insurance Building in 1925 — were the result of pressure on office accomodation from other organisations.

More serious, was the fact that the observation site for climatological measurements was also shifted several times after the Service was established. Starting with John Knowles' station half-way between the shoreline and Tinakori Hills in 1862, it was shifted by Hector in 1869 to a hill at the back of the Sydney St Cemetery, where a Time Observatory had been established. In 1906 this site was required at very short notice for the grave of the Premier, Richard Seddon, and the climatological enclosure was moved back to the Alexandra Barracks site close to the present National Museum, where it had been in the 1850s. In 1912 the Wellington City Council offered the Meteorological Department a small reserve on the Thorndon Esplanade, at an annual rental of five shillings, for as long as the land was not needed for railway purposes. An octagonal observatory was built and ceremoniously opened by the Minister of Marine on 6 June 1912.

The Service was required to vacate its offices in the Government Life Building in 1928, and the erection of a separate Meteorological Office in the Kelburn Observatory Reserve was approved; in the same year the climatological enclosure was moved from Thorndon to Kelburn. The new building was opened in September 1930, after a tender for £2560 was accepted in April 1930.

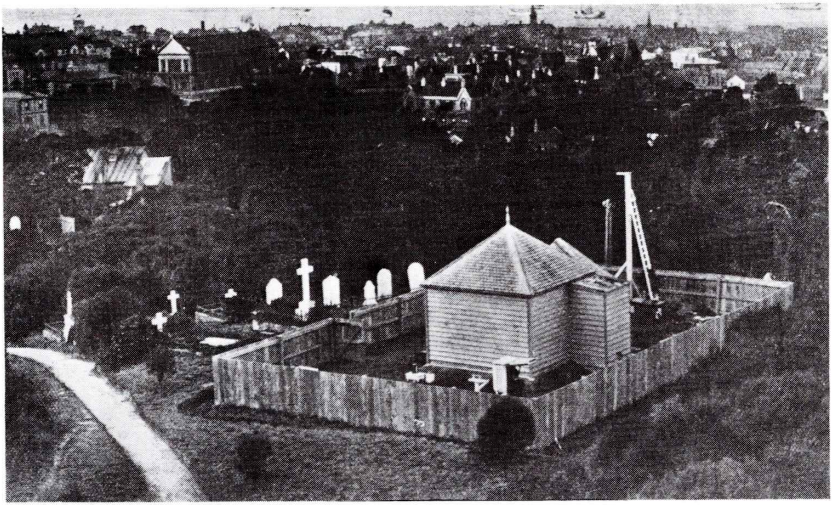
The Service was perhaps fortunate to get its new quarters at a time when the country was just beginning to slide into the economic depression of the 1930s. However, it was not long before its largest item of expenditure — communications — was once again the first target for retrenchment. On three separate occasions over the next three years, cuts were made and the reporting networks and forecast services reduced.

The financial restrictions caused Kidson to protest to Marsden on 22 February 1932 that: 'We have not now sufficient reports to know what the weather has been in all districts, which is essential for proper forecasting.' He pointed out that the provision of resources for meteorological services in New Zealand compared unfavourably with that in any other developed country except one, but that inspite of that, 'there is no comparison between the amount of useful information published since my arrival and that for all the preceding years.' He warned that it was useless to expect to retain a qualified meteorologist unless he was able to do satisfactory work and that he had remained in New Zealand only because he was assured that the Meteorological Service would not be further reduced. This latter was a reference to an offer from Australia for Kidson to fill the post of Director of the Commonwealth Bureau of Meteorology which had recently become vacant.

A further remonstration was made soon after this, by pointing out the waste of public money arising because of still uncoordinated meteorological activity in the country. The Public Works Department had recently bought 500 rain gauges, and both the Agriculture and Forestry Departments with their own climatological stations were further examples. The resulting data from all this effort, were in many cases unsatisfactory because of ignorance of observational procedures. Marsden's support and the publicity about the state of meteorological services brought a reinstatement of some activities that had been cut.

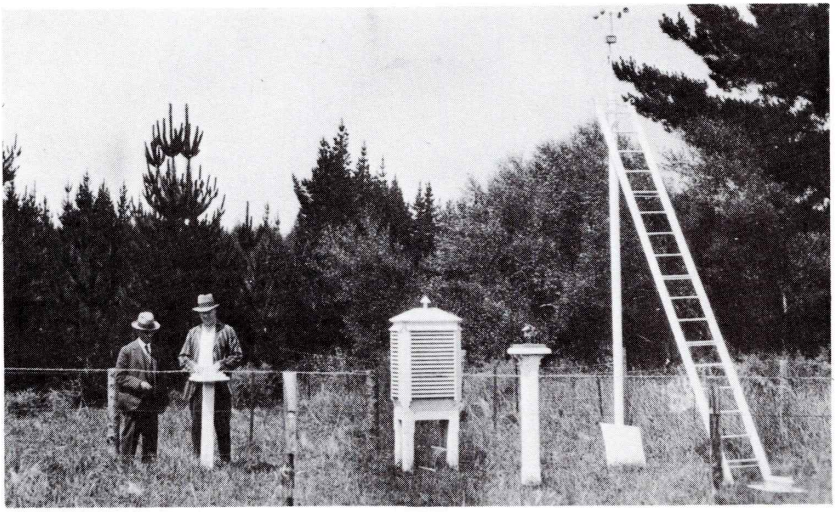
In August 1931, Kidson was invited to the centenary celebrations of the British Association for the Advancement of Science in London, as one of the delegation from the Australian and New Zealand Association. This time approval was given to attend — but at his own expense except for a grant of £150 from the British Association. After the meetings in London, Kidson at the invitation of Sir George Simpson, attended a meeting in Locarno of an International Meteorological Organisation committee. This was on the collection and exchange of meteorological information by telegraph, cable, and radio, and he was elected to the committee as the only southern hemisphere representative.

From Locarno he travelled to Bergen in Norway, to study the Norwegian



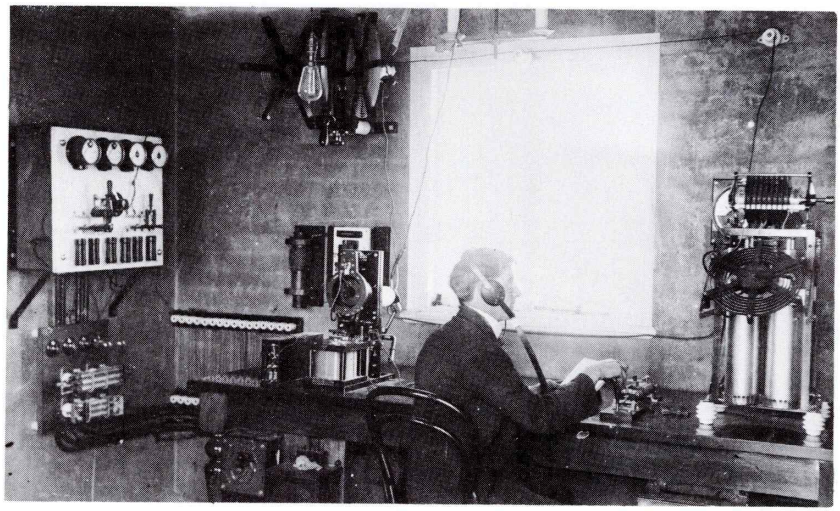
(Alexander Turnbull Library)

'Old Colonial Service Observatory' from the *Canterbury Times* of 27 June 1906. This building was erected in Wellington in 1869 and demolished in 1906 to make way for the tomb of the Premier, the Rt. Hon R. J. Seddon.



(Alexander Turnbull Library)

Climatological station at Hanmer 1930s.
The Service has always depended on other organisations and private individuals for most of its climatological and rainfall observations.



(Alexander Turnbull Library)

Telefunken radio equipment, Tinakori Hill, Wellington. Five sets were bought by the N.Z. Government in 1913 for communicating with ships at sea.

(Alexander Turnbull Library)

K. Kuring at the radio transmitter in the operator's cabinet off the forecast room, Kelburn. About 1938.

air mass and frontal methods of weather map analysis, and discuss their application to the Southern Hemisphere. From there a return to Britain — spending time in the London Meteorological Office; at Oxford discussing ozone measurement with G. M. B. Dobson who had recently developed his well known spectrophotometer; at the Agricultural Experimental Station, Rothamstead; and at the Fruit Research Station, East Malling.

This series of visits, covering many of the expanding interests of the Service, was of great benefit to meteorology in New Zealand, and redressed the losses incurred by Kidson's absence from the previous international meetings.

Weather forecasting — official and otherwise

Kidson's annual report for 1932–33 contains a long essay on weather forecasting, in which the points made, and the principles outlined, are as relevant today as when they were written. At that time the public awareness of the processes involved in making a forecast was even less than it is today, and it was not generally appreciated that deficiencies in theoretical knowledge, large gaps in the observation network, and spatial variability of the weather in a mountainous country, all imposed limits on accuracy.

In the circumstances, it was perhaps inevitable that there should be a proliferation of unofficial weather forecasters in competition with the State organisation. Kidson had little patience with them and complained of the dissipation of energy and attention they caused. Local newspapers are commonly the pulpit of private forecasters who at that time abounded from one end of the country to the other. There was F. L. Wooles 'who forecasts the weather from day to day so accurately for the *Star-Sun*', (Christchurch); P. H. Jones of Dunedin who invented an instrument by which the unskilled could make forecasts, and sold forecasts to the farmers for a year ahead; and H. M. Vincent who for years had his forecasts published in the Auckland *Herald* — above what was headed the 'Government Report'. Vincent wrote to the *Auckland Star* in 1938 commenting on the research in Antarctic meteorology:

> I notice that an attempt at making seasonal weather forecasts is contemplated by the Scientific and Industrial Research Department. I would point out that for 20 years I have been issuing seasonal weather forecasts with success. The numerous letters I have received from farmers and others testify to the remarkable accuracy of the forecasts . . .

He went on to say that as New Zealand is becoming more tropical, any study of Antarctic weather in relation to New Zealand was a waste of time.

The list could be extended, but the most interesting — and in a class by

himself — was without doubt Clement Wragge (1855–1922). A colourful personality, he was the first government meteorologist in Queensland, but left Australia when his application for the post of Commonwealth Meteorologist was unsuccessful in 1907. Wragge came to Auckland in 1910, and set up an observatory and forecasting service — besides being an indefatigable lecturer. He had wide meteorological experience in Europe and Australia, and while in Europe had studied the methods of seasonal forecasting, using astronomical cycles, propounded by the Austrian meteorologist Bruckner. He was one of the first meteorologists to give names to cyclones.* Wragge had a great local reputation in Auckland, and after his death his work was carried on to a lesser extent in the Waikato by his son Kismet.

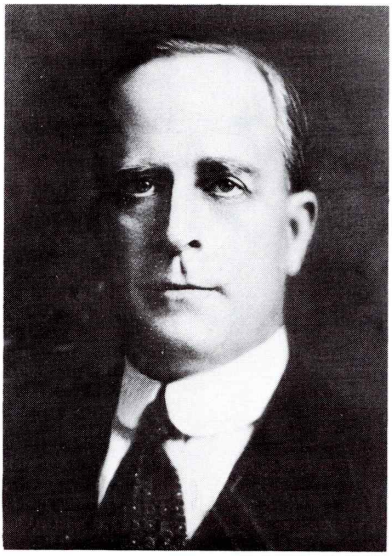
The private weather forecaster with his secret methods still occasionally appears today and often finds a market for his wares, but their number is much smaller than it used to be.

The Visit to New Zealand of Jorgen Holmboe

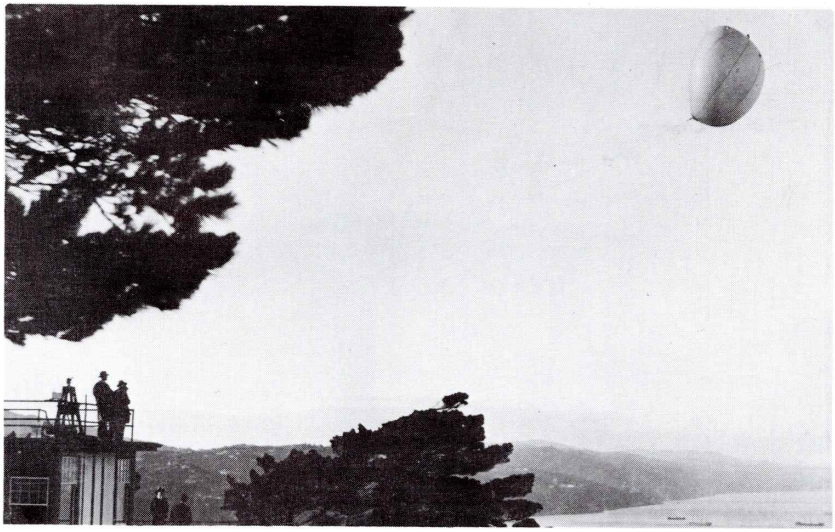
The year 1933-34 were of great importance in the development of meteorolmeteorology in New Zealand. Kidson heard from Sverre Petterssen, the Director of the Meteorological Institute at Bergen, that one of his staff, Jorgen Holmboe, had been appointed to the Ellsworth-Wilkins South Polar Expedition as meteorologist. Holmboe was to make upper soundings of both temperature and wind at the base station in the Antarctic, and also to produce forecasts for the aeroplane carried by the expedition. With his interest in antarctic meteorology, Kidson was asked to brief Holmboe when the expedition called into New Zealand on its way south. He saw the possibility of Holmboe remaining in New Zealand on his return from the Antarctic, to make some upper air temperature soundings in Wellington. Practically nothing was then known about the structure of the upper atmosphere in the Southern Hemisphere, and Petterssen agreed that any unused radiosondes could be flown in New Zealand.

On its way south the expedition ship *Wyatt-Earp* called into Dunedin, where the radiosondes were calibrated with a vacuum pump borrowed from the University, and Holmboe spent a week in Wellington discussing with Kidson the Norwegian methods of weather map analysis, as applied to the high latitudes of the Southern Hemisphere.

* In his booklet 'The Origins of Australian Meteorology' W. J. Gibbs says He (Wragge) began by using letters of the Greek alphabet, then drew from Greek and Roman mythology and progressed to the use of feminine names. Finally he used the names of politicians, many whom, being unpopular with Wragge, would find their name attributed to a cyclone which 'did not know what to do next' or which was 'whooping around and making a nuisance of itself as usual.'

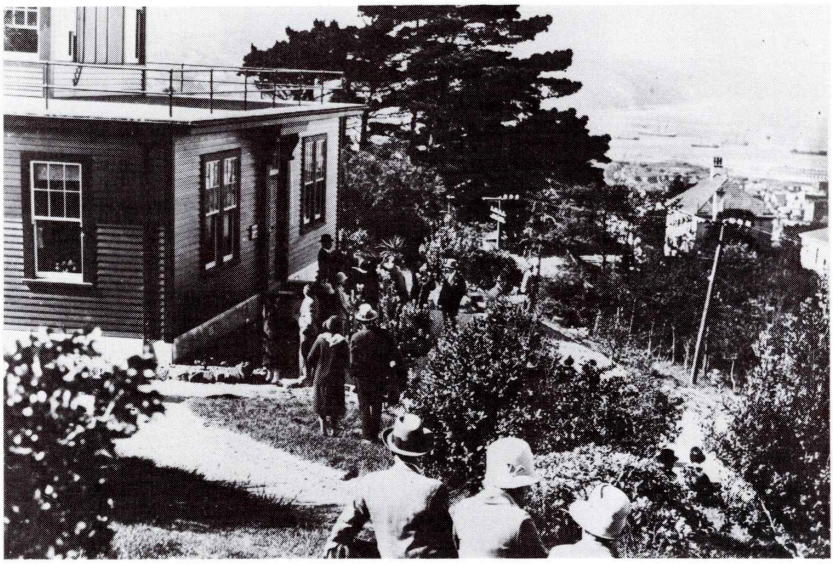


Dr E. Kidson

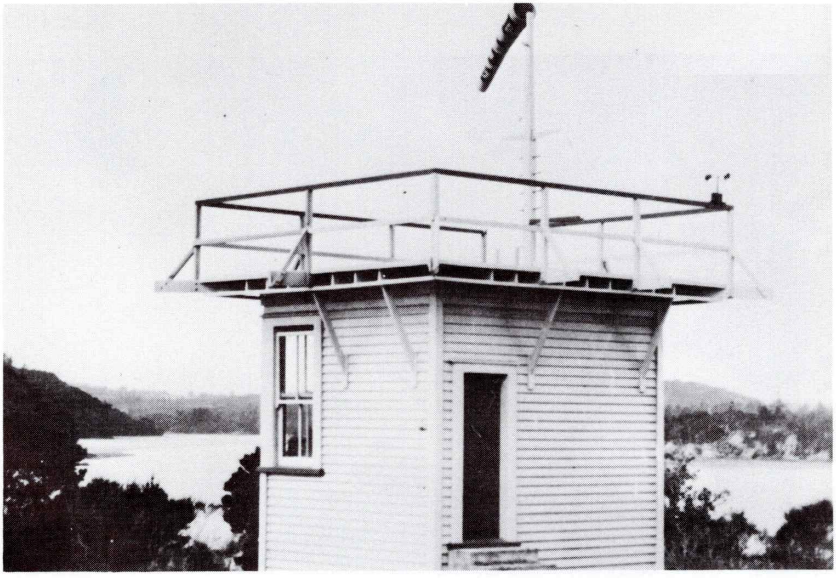


(Alexander Turnbull Library)

First radiosonde flights in New Zealand made in May 1934 at Kelburn by J. Holmboe and the staff of the Meteorological Office.



(Alexander Turnbull Library)
Official opening of the new Meteorological Office, Kelburn, 29 October 1930.



(Alexander Turnbull Library)
The anemometer hut RNZAF Base Hobsonville, 1937, which served as the Meteorological Office until accomodation was found in Auckland city in 1939.

The expedition arrived back in New Zealand in January 1934: because of damage to its aeroplane the stay in the Antarctic had been brief, and there had been no time for radiosonde ascents in the Bay of Whales, with only one unsuccessful attempt on the voyage back. It was expected that the *Wyatt-Earp* would make a new attempt to establish a base in the Weddell Sea the following spring, but in the meantime engine repairs required at least a two months stay. Holmboe agreed to spend the time in Wellington.

The proposed radiosonde flights in the Antarctic were sponsored by the Commission on the Polar Year 1932–33, and Kidson obtained agreement from the President of that Commission for the instruments to be released in New Zealand. In May 1934 the first temperature soundings in the country were made in Wellington, although the now familiar down draughts experienced at the elevated Kelburn site made initial launching of the large balloons difficult. The German and Russian instruments used were found to be far from perfect. However the results were interesting, with upper temperatures being higher, and the stratosphere lower, than had been expected. Holmboe assisted by Simmers carried out twelve flights, with four entering the stratosphere.

Holmboe's eventual seven months in Wellington were also valuable, for the opportunity they gave New Zealand meteorologists to obtain a thorough grounding in Norwegian air mass and frontal methods of analysing weather charts. Holmboe devoted a large part of his time to the analysis of the daily New Zealand charts — working mainly with Kidson and C. E. Palmer who had joined the staff in 1933 — and soon the daily weather maps were being plotted and analysed in the Norwegian style. The time that Holmboe spent in New Zealand saw the beginnings of temperature soundings in the upper air, and of the application of the methods of weather map analysis universally used today.

Forecasting for aviation

After the careful preparation for the first trans-Tasman flights, the arrangements for some of the succeeding flights in 1934 had been haphazard. The Meteorological Service was given no, or incorrect, information on flight details — it had been thought that Kay and Hewitt who landed at Westport were going to Auckland, while Whitehead and Nicholl who were expected at New Plymouth landed in North Auckland!

In 1934 Kidson proposed a scheme for reorganising the weather forecasting services, which required three additional meteorologists, new branch offices at Auckland and Christchurch, and the regular reception of all Australian weather reports. The Government gave an assurance that the meteorological

services needed for aviation would be provided as soon as the necessity arose, and extra staff and facilities were made available in piecemeal fashion. Many of those who later became responsible for coping with the explosive growth of the Service during the 1939–45 War were recruited about this time.

L. N. Larsen joined the Service in 1934 from the Magnetic Survey, Christchurch, followed closely by J. F. Gabites from the same organisation. Dr M. A. F. Barnett, who was to succeed Kidson as Director, joined in 1935. He made fundamental contributions to ionospheric research while at Cambridge University and returned to New Zealand initially as a physicist with the DSIR. He was seconded to the Meteorological Service to take charge of its aviation section. Barnett was soon joined by Dr W. A. Macky who had been trained in the Meteorological Office, London. In May 1935 the Government agreed to establish a branch Meteorological Office at the RNZAF base at Hobsonville, Auckland, and Macky was appointed to take charge.

The development of aviation meteorology in New Zealand was initially handicapped by lack of a unified communications system. While a Controller of Civil Aviation had been appointed in 1931, the Post and Telegraph Department was still mainly responsible for communications. With private aero companies preparing to install their own communications and navigational aids, and with no co-ordinating authority, chaos seemed inevitable. By 1935 the situation had not improved, and Kidson wrote to Marsden recommending that the whole communications system for aviation should come under the technical supervision of the Department of Civil Aviation, — as under the conditions then existing, officers of the Post and Telegraph Department were being called on to decide technical questions concerning aviation.

In spite of only a telephone link with some airfields, the Meteorological Service was able to give an acceptable service to aviation, but it was put in an impossible position however, when both 'Cook Strait' and 'Union Airways' decided to fly on Sundays. The Service did not have enough staff for weekend work, while the observational network on which the forecasts depended was much reduced on Sundays and few telegraph offices were open. Kidson estimated that the additional cost to provide Sunday service would be £1700 a year, and said that 'presumably if agreed to, the service would have to be financed by Air Services.' The user was not however called on to pay, and towards the end of 1936 the Government approved funds to enable the Meteorological Service to give aviation forecasts on Sundays and public holidays.

Antarctic meteorology

Dating from his time with the Commonwealth Bureau of Meteorology, Kidson

was actively interested in Antarctic meteorology. He wrote a critical study of the meteorological records of the first Shackleton Expedition (1907–09), and while in Wellington worked on a similar discussion of the results from Sir Douglas Mawson's 1911–14 Expedition. The New Zealand Government agreed to contribute £2500 to Mawson's 1929–30 expedition, partly because of its interest in Antarctic hydrography, and partly because of Kidson's earlier researches on the possibility of a relationship between the weather of the Antarctic and New Zealand. Marsden suggested that two New Zealand scientists be seconded to the expedition, and R. A. Falla (a biologist with the Education Department) and R. G. Simmers were appointed.

The expedition vessel *Discovery* was due to leave England for Cape Town in August 1929, where the scientific staff would be picked up and then proceed to the Antarctic coast in the sector 50–90 °E. Simmers spent the three months prior to this in London, dividing his time between the expedition headquarters, Kew Observatory, and the Meteorological Office in South Kensington arranging the meteorological instruments for the expedition, and joined the *Discovery* in Cape Town. Besides regular routine weather observations, Simmers was responsible for upper wind and temperature measurements, solar radiation, atmospheric turbidity, micro-meteorological measurements, and magnetic observations.

Mawson requested the services of both Falla and Simmers for the second and final cruise of the *Discovery* the following year. This expedition left Hobart on 2 November 1930, returning on 19 March 1931. Simmers joined the ship in Australia and the same meteorological programme was carried out as in the previous year. Seaplane flights enabled much of the coastline to be charted, and on behalf of Australia Mawson claimed the sector of the continent between 138 °E and 60 °E.

These two expeditions were the first in which an officer of the Meteorological Service had taken part, and began an association of the Service with the Antarctic which still continues.

An international scientific programme to investigate the polar regions was planned for the fiftieth anniversary of the first 'Polar Year' of 1882–83. Kidson was the secretary of the meteorological committee, although most of the activity was to be in the northern polar regions, as neither the European countries nor the United States contemplated an expedition to the Antarctic.

The economic depression was a difficult time to raise money for polar research, and a 1931 campaign in New Zealand to raise £10,000 for an Antarctic expedition was unsuccessful; nor would the Australian Government support an expedition to either the Antarctic or to the sub-Antarctic islands. In the end, New Zealand's contribution to the 'Polar Year' was confined to

Kidson's personal efforts, and a grant of £365 (£200 from Government and £165 from public subscription) to install and operate a set of magnetographs at Amberley, Christchurch. These were loaned by the International Polar Year Commission and operated by the Christchurch Magnetic Survey. Within the limits of its budget, the Meteorological Service was able to keep its observational programme going.

Research and recruitment

The 1935 conference of Empire meteorologists in London, and the following meeting of the International Meteorological Organisation (IMO) in Warsaw, were both attended by Kidson. His very full reports on these meetings and comments on the overseas developments in meteorological research, show his thoughts on the place of research in a national meteorological service, such as his own. He remarked that:

> In my opinion a healthy tone can only be maintained in a service if there is some provision for research during office hours and if definite steps are taken to encourage it by leadership and provision for free discussion. The surroundings also, must be congenial.

He contrasted the conditions he saw in the London Meteorological Office, where professional staff in cramped quarters were fully occupied with routine duties, with those existing at Bergen in Norway — there, meteorologists spent part of their time on weather forecasting duties and part on research, and there was close liaison with the nearby Meteorological Institute and other research institutions. As a result, a number of very able people had been given encouragement and time for research, and Norway had become a world leader in meteorology. In a letter to Marsden accompanying his report, Kidson specifically asked that Marsden note the remarks on research.

With a view to extending the training of its scientific staff, the Service arranged leave of absence for overseas study. In 1936 Simmers won a Commonwealth Fellowship, and went to the Massachussetts Institute of Technology for doctoral studies in meteorology, thus beginning an association of New Zealand meteorologists with that institution which still continues.

There was no source of trained meteorologists in New Zealand, and in order to recruit suitable staff for the expanding Service, university graduates in either mathematics or physics were employed. Technical training in meteorology was given on the job, and by March 1937 the total staff of the Service was eighteen, including twelve professional meteorologists.

Further expansion for aviation

With the establishment of regular commercial air services, the provision of

meteorological information for aviation became a principal concern of the Service, and branch offices were established at RNZAF stations at Wigram and Hobsonville, each with a staff of four. The inability of the Defence Department to provide accommodation at Hobsonville delayed the start of operations there until May 1937. The anemometer hut served as the meteorological office and the only furniture was an old school desk which was also used for RNZAF examinations. Wing Commander the Hon. Ralph Cochrane, the first Chief of Air Staff, was not sympathetic to the establishment of a meteorological office at Hobsonville. He did not approve of civilian staff on the base, or a meteorological office for Auckland city being situated there, and in his view, aviation needed only a few route weather reports on internal flights. As for trans-Tasman flying,

> . . . for the first few flights they [the aircrew] would undoubtedly want to consult a meteorologist but the weather is becoming less and less important and after a short time the pilots would want a collection of route reports only.

Although the office was eventually established it did not remain at Hobsonville for long. Early in 1938, it was ordered to vacate the RNZAF base at Hobsonville as quickly as possible, and found temporary accommodation towards the end of 1939 in the City, moving from there to Mechanics Bay in November 1939 with L. N. Larsen, as officer-in-charge.

The Wigram office had opened in July 1937 under Larsen, to provide a complete weather observation and forecasting programme, and to instruct RNZAF aircrew trainees in meteorology. Two pilot balloon flights were made daily, with upper air temperatures and humidities measured whenever possible in special aeroplane flights to about 16,000 feet (a total of 125 flights in 1938–39). Weather maps were drawn daily and forecasts issued to the RNZAF, civil aviation, and the general public.

Meteorological services in the Pacific

With the growth of trans-ocean flying it was expected that Apia would be an important centre for the collection of Pacific Island weather reports, and the dissemination of forecasts. In a memorandum of 6 February 1936, Kidson urged the Government, through Marsden at the DSIR, to upgrade the meteorological services at Apia, Western Samoa, which had been under New Zealand control since 1920 as a League of Nations mandated territory. He pointed out the importance to New Zealand of maintaining control of the meteorological services in the South Pacific, in the face of a possible military threat from Japan and a resulting American take-over in the area. He recommended that:

1. New Zealand should be responsible for aviation meteorological services in the area,
2. The New Zealand Post and Telegraph Department should be asked to state the changes in existing radio stations necessary for the collection of Island weather reports at Suva and Apia,
3. The Director of the Apia observatory should be asked what additions to his staff would be needed to ensure adequate weather reports, and
4. The Navy should be used for the inspection of Island stations and training of local observers.

The proposals produced no reaction, and little was done to upgrade the Pacific Islands reporting networks.

However Government approval was obtained for New Zealand to host a regional conference in 1937, to make arrangements for radio links and meteorology in the South-West Pacific for trans-ocean aviation. Invitations were accepted by Britain, the United States, Australia, Fiji, and Samoa. The New Zealand Post Office, Civil Aviation, and the RNZN were also represented at the meetings in Wellington from 29 November to 3 December 1937.

A complete communications and meteorological system modelled on trans-Atlantic aviation experience was adopted, and the 'aeradio' committee of the conference made satisfactory temporary arrangements for radio transmission and reception in New Zealand. These were all in place before the flying boat *Centaurus* of Imperial Airways arrived in Auckland on its survey flight.

The campaign for upgrading the services in Fiji, a Crown Colony, was continued by urging Capt. Garbett of the Royal Navy Meteorological Branch to use Navy influence to persuade the British Government to provide the funds. Sir George Simpson of the Meteorological Office, London, was also approached with the same request. When unofficial moves brought no action, Kidson sent memoranda in April 1939 to the Controller of Civil Aviation and to the Secretary of DSIR, outlining the requirements for a meteorological service in Fiji. His requests that the British Government and the High Commissioner for the Western Pacific be written to, urging immediate action, were sent on to the New Zealand Government for approval.

The Meteorological Service in New Zealand

The retirement of Pemberton in 1938 removed from the Service the only senior officer, besides Kidson, with extensive experience in weather forecasting and climatology. Since joining the Service in 1910, he had played a large part in the maintenance of the routine activities, and had deputised for both Bates and Kidson on their absences from Wellington. The Service owed him a great deal.

Although the training of young meteorologists had gone on as quickly as possible, the pool of practical experience, especially in weather forecasting, was small. By force of circumstance those with two or three years experience became the 'old hands'. This threw an additional load on Kidson who besides being involved in the operational activities of forecasting, climatology, and administration, also pursued his personal scientific researches.

It was thus a great loss for the Meteorological Service when Edward Kidson died suddenly on 12 June 1939, at the age of 57. When he was appointed in 1927 the staff numbered five; when he died, it was over forty and included twenty professional meteorologists. Kidson had put the Service on a firm scientific basis, and shown how an adequately funded and staffed National Meteorological Service could make contributions to the community. He was convinced that an organisation, which concentrated on the services aspect to the exclusion of research, would become sterile. Although Kidson was a reserved man, not given to unnecessary words, his ability and leadership secured him the respect of his staff.

Kidson's scientific work in meteorology covered a wide field. His contributions in Southern Hemisphere atmospheric circulation, and especially that of the Antarctic, brought him an international reputation. His last work on the observations made on the 1911–14 Mawson expedition was published after his death. He introduced the Norwegian methods of weather map analysis to this region, and his papers on New Zealand's climate remained standard works for many years.

It is interesting to review the state of the Service as Kidson left it: change and growth had been forced on it, and the expansion of civil and military aviation brought great scientific and organisational changes. The movement for co-ordination and expansion of government science in New Zealand, culminating in the establishment of the DSIR, had included meteorology as an essential element; and Marsden's enlightened ideas on the role of a state meteorological service, and his part in bringing Kidson back to New Zealand, ensured that the maximum support would be given when resources to achieve expansion were needed.

The level of support, however, had severe financial constraints. The economic depression of the 1930s coincided with the period of expansion, and the planned changes needed both Kidson's determination and Marsden's support. Marsden's support was often limited by political decisions, and interference and delay from administrators 'who did not take science seriously (and frankly thought it humbug) . . .'

By mid-1939 the scientific staff had increased to twenty-one. Dr Simmers returned from MIT, and Dr C. J. Seelye, a statistician and applied mathe-

matician, joined the staff as a climatologist. The branch office in Auckland had four, and Christchurch three, meteorologists with supporting staff. The observational networks upon which the work of the Service depended consisted of:

78 stations, including the Chatham Islands and Raoul Island, whose reports were used for the drawing of synoptic charts.

60 climatological stations.

520 rainfall stations, largely manned by voluntary observers. As well there was close liaison with the Public Works Department and the Department of Agriculture, both of which had rainfall networks for special projects.

Dines pressure tube anemometers operating at Auckland, Wellington, Christchurch, Ohakea, and Paraparaumu.

Public weather forecasts were broadcast generally by national radio, which largely superseded the use of the telegraphic service to sent out individual forecasts. Special forecasts to farmers were broadcast daily, as were aviation forecasts, and a selection of weather reports.

The communication system had been upgraded, and a large part of the transmission and reception of weather messages by radio took place in the forecast room at Kelburn. Initially all weather messages were received by morse land-line from the General Post Office in Wellington, where there was one operator seconded from the Post and Telegraph Department.* Later a shortwave receiving set was installed to copy the broadcast from Australiá, and a tape printer added to handle inland weather messages.

* An uncommon versatility in processing the incoming reports was sometimes shown in emergency by J.F. Gabites, a later director, who took down the morse radio messages, plotted and analysed the weather map, and issued the forecasts.

4

The war years 1939-45

After Kidson's death Dr M.A.F. Barnett was appointed Director on 15 June 1939. His immediate task was to implement already existing plans for the continued expansion of the Service, made necessary by the growth of both military and civil aviation — while the outbreak of war soon afterwards greatly increased the scope of the meteorological services that had to be provided. Decisions on the role of the Service in the event of war had been taken some time before. In 1936 the New Zealand Committee of Imperial Defence (later the Organisation for National Security, ONS) set up a Meteorological Committee and later a Communications Committee.

For their first two years these committees, which worked closely together, were concerned with the maintenance and extension of meteorological services in the South-West Pacific. Kidson had produced a plan which was recommended to the Government for adoption, and both Australia and New Zealand realised that if they did not set up adequate meteorological and communications networks, then Pan American Airways would itself provide them for its flying boat services. Kidson had also pointed out earlier that questions of national sovereignty over facilities and territories were involved. The two Governments agreed that New Zealand would be responsible for aviation weather forecasting in the South-West Pacific, excluding New Caledonia and the New Hebrides, and a temporary radio and meteorological station was set up on Raoul Island in the Kermadec Group.

The British Government had defence responsibilities in the Pacific, because of its colonies and trust territories. On 11 October 1938 the Secretary of State for Dominion Affairs in London, sent New Zealand a memorandum on the nature of the meteorological reports that would be needed by the British armed forces in the Pacific in the event of war. It was largely in broad terms, except on the necessity for the cessation of ship reports, and the use of a confidential code when meteorological messages were sent by radio.

The ONS Meteorological Committee filled in the organisational details for New Zealand and its Pacific area, needed to comply with the British request. Communications would be by landline, teleprinter, and radio within New

Zealand; and cable and radio would be used to connect New Zealand with Australia and Pacific Island main centres.

Transfer to the Air Department

Suggestions on the status of the Meteorological Service in war-time were made by the DSIR to the ONS on 7 June 1939. It was envisaged that the Service would be part of the military organisation, with a proportion of the staff (including the Director) being given military rank on the outbreak of war. A precedent for the inclusion of some meteorologists in the armed forces had been set by the British Army in 1914-18, but here mobilisation and manpowering of the whole Service was suggested. In order to retain all scientific and technical staff, their recruitment into other branches of the armed forces would be prohibited.

The ONS Meteorological Committee's recommendation, that the Meteorological Service be transferred from the DSIR to the Air Department on the outbreak of war, was approved by the Council of Defence on 26 August 1939. Although the transfer was considered by both the DSIR and the Meteorological Committee to be a temporary war-time arrangement, there were others who had different ideas, preferring a peace-time meteorological service to be under the direct control of aviation interests.

Because of the large aviation servicing content in the work of the Meteorological Service, the Air Department began to make grants to the DSIR as reimbursement for the costs of providing these services. In the year ending 31 March 1940 the DSIR Vote of £24,000 for its Meteorological Office was offset by a credit of £15,000 from the Air Department. Under these circumstances the Air Department sought administrative control over the Meteorological Service, the suggestion first surfacing officially in March 1939 at a meeting of the combined Meteorological and Communications Committee of ONS. Under discussion on the allocation of costs for meteorological communications, the Controller of Civil Aviation said that, although he considered that the Meteorological Service should be under Air Department control, the question was one for the appropriate Ministers to decide.

It was only a matter of time before the idea was brought to ministerial notice. A year later the Controller of Civil Aviation, this time as chairman of an 'Aeradio' committee, wrote to the Air Secretary proposing a takeover. The suggestion was sympathetically received, and resulted in a recommendation to the Minister of Defence.

The Minister in charge of the DSIR, however, took the view that a change in organisational control was not wise, on the grounds that, although aviation requirements dominated the weather forecasting effort, the climatological and

research activities would be in danger of being overshadowed if the Service was to go under Air Department control. He saw little advantage in such a step, which he considered unnecessary.

The outbreak of war soon afterwards settled the question, and Cabinet granted the necessary authority for the transfer on 4 September. For the remainder of the financial year the costs of the Service were a charge on the DSIR Vote, but thereafter on the War Expenses Account.

There were some misgivings in DSIR that the change would become a permanent arrangement and not just a war-time expedient. Ministerial assurances of the temporary nature of the transfer were sought and received, with the proviso that a review of the situation should be made at the end of the war to ensure that a move back to DSIR would result in greater efficiency.

While it was realised in DSIR, that this proviso seemed to put it in the position of having to justify a case for the peace-time retention of what had been one of its own Divisions, it was decided that the advantages of administration under a central scientific organisation were so self-evident as to make the transfer back to DSIR a relatively simple matter when the time came. These assumptions were later proved to be quite without foundation.

Mobilisation into the RNZAF

The outbreak of war had brough the Meteorological Service under Air Department control so that the needs of aviation in general, and the RNZAF in particular, could be better met. However, satisfactory organisational arrangements were not made until February 1942. Until that time, the Service was a civilian organisation working largely in a military environment, which brought minor problems of divided control — especially for those members who were working on RNZAF stations. More seriously, as a civilian organisation the Service was effectively prevented from recruiting the necessary extra staff needed to cope with increasing military demands.

At the time the manpower requirements of the military forces were paramount. Any new recruits to the Meteorological Service were soon called up for military duties, and could be retained only if they were specialist meteorologists (which they hardly had time to become), or were not physically fit.

Some slight alleviation in the observer (support staff) position was found to be possible through RNZAF regulations. These were based on RAF regulations which included the category of meteorologist among the list of trades for airmen, and this provision was used to get extra observers for RNZAF stations — but had only produced sixteen by the end of 1941.

The obvious solution was the complete mobilisation of the Service into the armed forces. There were, however, objections to this from both Treasury and the Government. The sticking points were financial: mobilisation into the RNZAF could mean that the appropriate ranks for some meteorologists would bring a higher rate of pay than their civilian salary, and there was also the possibility of faster promotion in the RNZAF than in the civilian service which, it was thought, might cause difficulties on demobilisation. These possibilities were unacceptable to both Treasury and the Minister of Finance.

Barnett continued to press for complete mobilisation, and in October 1940 presented the Air Board with a proposed rank and salary for each member of his service, the pay and allowances corresponding to their civilian salary. The proposal was referred to Treasury which, after consultation with other Government Departments, came up with a compromise which did nothing to remedy the impossibility of recruiting staff.

On 20 June 1941 Barnett informed the Chief of Air Staff that with his existing resources he could not provide the meteorological services likely to be needed by an expanding RNZAF. The Chief of Air Staff recommended to the Minister of Defence the immediate mobilisation of the Meteorological Service, pointing out that any financial advantage that might accrue to some individuals, was minor compared with the advantages to the RNZAF. Treasury did not agree.

By the end of 1941 the possibility of the extension of the war to the South Pacific, and the deployment there of the RNZAF brought fresh urgency for an expanded Meteorological Service. Not without opposition, a compromise was eventually reached whereby the Service was to be mobilised into the Administration and Special Duties Branch of the RNZAF. Staff of the Service would be on the same footing as the permanent military forces and be liable for income tax and have to contribute to the goverment superannuation fund (these restrictions were later relaxed). A fresh schedule of proposed salaries cleared the Treasury hurdle and was approved by Cabinet on 3 December 1941; and on 1 February 1942 the Meteorological Service went into uniform.

The penny pinching, negative attitude adopted by the Government and some of its advisers, over mobilisation of the Service, made growing pains much worse than they need have been. Without the needless delays, a larger and more efficient organisation would have been in place when it was urgently needed after the entry of Japan into the war.

The Service had to live with this attitude until the end of the war. Its officers found themselves subject to discrimination and none received normal promotions given to other specialist branches of the RNZAF.

Mobilisation of the Service into the RNZAF produced no real changes in its functions, but the way was opened for the recruitment of enough staff to cope with the demands of a rapidly expanding Air Force. From the outbreak of war until mobilisation, the number of professional meteorologists had changed from 28 to 31, while observers and other support personnel had grown to a total of 59 by the beginning of 1942. By the end of the war the Meteorological Branch of the RNZAF numbered 63 officers, and 274 support staff.

Throughout its association with the RNZAF, the Service retained a system of centralised control from its directorate in Wellington. When dealing with technical matters, the outstations and the units attached to RNZAF stations could communicate directly with the headquarters of the Service in Wellington. The normal RNZAF group organisational structure did not apply then, and only in personnel matters were the usual Air Force channels of command used. The successful operation of this flexible arrangement required tolerance and mutual co-operation, which on the whole was successfully achieved.

The RNZAF required its meteorological branch to provide specialist units at all its training and operational stations. Duties included lectures to aircrew, and the provision of weather forecasts for local and cross country flying, reconnaissance flights over the oceans around New Zealand, and eventually for the transport and operational squadrons in the Pacific.

The rapid increase from 1942 onwards in the number of RNZAF stations, both within New Zealand and in the Pacific, necessitated a rapid deployment of trained meteorologists and observers, and of equipment. The appearance of American weather officers and men in the South Pacific, in June 1942, brought with it the added task of Allied co-operation and planning to make the best use of all the meteorological resources in the area.

Staff and training

After February 1942 the war-time staff consisted of professional meteorologists, temporary staff recruited as weather forecasters and commissioned as officers in the RNZAF, meteorological observers (both permanent staff and temporary, who became NCOs, airmen and WAAFs), and technical and clerical support staff. The only civilian staff were some clerical personnel, and local native observers in Fiji and Western Samoa.

The pre-war requirement of a university degree for weather forecasting duties was retained; however, as a war-time measure some people with advanced training in subjects other than physics and mathematics were accepted for training. This academic barrier to weather forecasting duties caused some criticism at the time from able observers, but while there may

have been some injustices, on the whole the system worked well.

The training of professional meteorologists before the mobilisation of the Service was done by individual study, and by working alongside someone with more experience. This rather leisurely apprentice-type system was satisfactory only when small numbers were involved. Even in 1939 we find Kidson saying:

> Conditions have in many ways been difficult owing to the need to train so many freshly appointed officers at the same time. As soon as one officer has mastered the rudiments of any branch of the work he has to make way for another. It will, naturally, be some time before the new staff can reach full efficiency. In the meantime, an added burden is placed on those who have had more than a year or two's experience.

With the need for the rapid production of more weather forecasters, an intensive training programme was started in 1942. Four courses for forecasting officers were held, one each year, from 1942-45. Training was given in the theory of synoptic meteorology and in weather forecasting techniques, and those who successfully completed the courses were commissioned as Pilot Officers. Training was given as junior forecasters under supervision, before eventual posting as meteorological officers.

The training was initially conducted by C. E. Palmer, who had returned to the Service from university in 1939 — later taken over by J. W. Hutchings. It was evident, even before mobilisation of the Service, that with an expected theatre of war in the Pacific, the Service needed to gain experience in tropical meteorology. The problems of tropical weather forecasting were known to be different from those in middle latitudes, but were then little understood, so Palmer studied the subject and conducted two refresher courses for forecasters in 1942-43.

Some months before mobilisation Barnett suggested to the Air Secretary that women should be enlisted for observing duties. This was adopted and was highly successful. Trained airmen were needed in large numbers in the Pacific, and WAAF personnel replaced them as far as possible on RNZAF stations in New Zealand and, from 1944 onwards, in the Fiji Meteorological Section at Lauthala Bay.

Prior to the need for a large increase in numbers, the training of meteorological observers was also by individual instruction. Observers were expected to acquire skills in taking surface weather observations, the use of the theodolite and slide rule in the calculation of upper winds by observation of pilot balloons, and the plotting of observations on charts for analysis by the forecaster. Later in the war some were required to operate wind finding

radar, and also radiosonde equipment for the measurement of temperature, pressure, and humidity in the upper atmosphere.

In order to produce the large numbers required, full-time training schools were operated on RNZAF stations, first at New Plymouth, and later at Woodbourne, Ohakea and Wigram. Eighteen courses were held during the war and about 300 observers trained. The testing of the recuits at the end of the courses was carried out by meteorological officers, but under the auspices of the RNZAF Central Trade Test Board.

A special school for the training of observers in the operation of radiosondes was held in Taieri in 1945, while at Ohakea instruction was given in the use of army ground location radar for upper wind determination.

Increase in branch office numbers

In 1939 additional branches were opened to serve RNZAF needs at Ohakea and Woodbourne, but because of the shortage of trained staff, the number of branch offices remained at five until mobilisation of the Service into the RNZAF. Wellington was the centre for the provision of meteorological information to the public and shipping, and contained the climatological, research, training, and equipment sections.

Auckland was mainly concerned with trans-ocean aviation services, and the needs of the nearby RNZAF stations. Wigram provided lectures to aircrew trainees, and undertook local weather forecasting as well as a forecasting service for the RNZAF.

During 1942-44, with the availability of more staff and because of the large number of new RNZAF stations, branches were opened at New Plymouth (1942), Rongotai (1943) (to take over aviation forecasting in Wellington), and Taieri (1944). Junior forecasters, dependent on either Wellington or Auckland, were put in charge of small offices at Waipapakauri, Whenuapai, and Nelson.

NCOs were in charge of small units to give direct contact with aircrew, and carry out weather observing duties at Onerahi, Mangere, Tauranga, Palmerston North, Hokitika, Ashburton, and Harewood. All were started in 1943. Similar offices were set up at Ardmore and Awarua in 1944, while there were temporary stations at Rotorua, 'Delta' (near Blenheim) and Levin during the period that the RNZAF had initial training Wings for aircrew there.

These stations formed the basic weather observing network in New Zealand for both surface and upper air observations. They were supplemented by surface observations from Post Offices and other Government agencies. The radio, telephone and teletype facilities provided by the Post Office had to be increased to cope.

Meteorological censorship

For over four years during the war all meteorological information disseminated by radio was, for security reasons, first encyphered. This tedious mechanical process, carried out manually, added considerably to the work of the meteorological sections throughout the Pacific area, and put a premium on the accurate transmission and reception of daily coded messages with their hundreds of numerical groups.

The necessity for keeping meteorological information confidential in the event of war had been drawn to the attention of the New Zealand Government by the Secretary of State for Dominion Affairs in 1938. All weather reports from ships were to cease, and a confidential code used when messages were sent by wireless telegraphy.

However, the imposition of secret codes for weather information transmitted from New Zealand did not start immediately on the outbreak of war. In July 1940 the New Zealand Government considered that in spite of enemy raiders in New Zealand waters, and the sinking of the trans-Pacific liner *Niagara*, such a step was not then necessary. It would be taken in consultation with Australia on the advice of the Navy.

Meteorological censorship was introduced in December 1940. Shipping interests in and around New Zealand were catered for by the supply of confidential information to harbourmasters and to some shipping companies. There were also broadcasts in code twice daily of forecasts and bulletins containing some New Zealand, Australian and Pacific Island reports.

Farming interests were not happy with the blackout on weather information. Representations made by the N.Z. Farmers Union in March 1941 brought some relaxation, and the Government agreed to the daily distribution of weather forecasts to 117 Post Offices throughout the country, and their public display on week days. Farmers continued to press for even more. Meteorological censorship was not completely removed until June 1945, though there had been a partial relaxation the previous September.

Establishment in Fiji and the South-West Pacific

The outbreak of war in August 1939 brought a new sense of urgency in New Zealand, to the need for providing an adequate meteorological service in the South-West Pacific. The possible requirements of greatly expanded military aviation were added to those of civil trans-ocean flying. Nothing however, could be done without the concurrence of Britain, whose colonies and trust territories were involved, and these were far from the areas where Britain had more urgent concerns.

A defence conference in Wellington in September 1939 recommended that the meteorological organisation in Fiji should be extended, so that Suva could act as a weather forecasting centre for aviation. It was appreciated that New Zealand would have to share the cost of such a service.

When these points were taken up with the Governments of Britain and Fiji, the resolutions of the meteorological conference of 1937 held in Wellington attended by representatives of Britain and Fiji were also referred to. The views of the British Government were sought on the allocation of costs, estimated at £3000 for capital and £3000-£5000 for annual running expenses Enquiries were also made about the provision of a qualified meteorologist to take charge of the forecasting services.

Dr Barnett took advantage of the survey flight to Fiji of the flying boat *Aotearoa*, to go to Suva in October 1939 for talks with government officials there, and with him went W. R. Dyer, a meteorologist from the Auckland Office of the Service with experience in tropical meteorology in Apia.

Meanwhile, a secret despatch from the Secretary of State for Dominion Affairs had been received in Wellington, containing a request from the Admiralty that New Zealand should plan for a 24-hour forecasting service at Apia to be effective in the event of the war spreading into the Pacific. The previous New Zealand approaches to Britain regarding the setting up of such a service in Fiji were ignored.

The New Zealand Chiefs of Staff did not agree with the Admiralty suggestion: they recommended that, in the interests of naval and aerial defence, and of civil aviation, the forecasting centre should be in Fiji. Suva was already on the routes of both American and British flying boat services, and had the better facilities. These opinions and recommendations were sent to the British Government for Admiralty comment.

No reply was received in the first half of 1940. It was evident to Barnett that unless New Zealand took the initiative, negotiated with the Fiji Government, and produced plans for a meteorological service, extension of hostilities to the Pacific would find no weather forecasting organisation in place. On Barnett's recommendation, the Chiefs of Staff Committee of the ONS agreed that an officer of the New Zealand Meteorological Service should be sent to Fiji without delay. His task would be to advise and assist the Fiji Government to produce plans for an organisation to meet the weather forecasting needs of the region, in the event of war in the Pacific.

Arrangements were made for W. R. Dyer to go to Fiji on 24 June for three months, and the British Government was given two days in which to voice objections. New Zealand offered to bear the costs incurred in the meantime and their ultimate allocation would be decided later. Britain, no doubt

thankfully, agreed subject to Fiji approval and Dyer left Auckland on the vessel *Matua* on 9 July 1940.

The Fiji Meteorological Service at this time was under the control of the harbourmaster, Capt. G. G. Nasmyth, with one assistant L. V. M. Osborn. Fiji had a network of climatological and rainfall stations, from which the climatic statistics for the colony were produced, and two weather charts were drawn daily from which local forecasts were issued, in spite of the few weather reports received.

Dyer's visit resulted in a joint report from the Fiji Colonial Secretary, Capt. Nasmyth, and Dyer himself. It recommended that because of the urgency, a Fiji Meteorological Service should operate as a branch of the New Zealand Service with its Director having wide local powers. A permanent, independent service could then be established at some later date, on normal Colonial Service lines. The report suggested several sites for a building for the expanded service, and gave sketch plans for a site at Suva Point close to the airport facilities.

No recommendations were made on the funding of the project, estimated to be £6600 in capital costs and £3300 in annual recurring costs. The Governor of Fiji sent the report to New Zealand with his general agreement, and a suggestion that the costs would be fairly distributed if New Zealand were to bear 50 per cent, Britain and Fiji 20 per cent each and the Western Pacific High Commission 10 per cent.

In the meantime the British Government had amplified its previous acceptance of New Zealand's proposals, and asked that she assume responsibility for a Fiji Service — on the understanding that agreement could be reached on the division of costs, and that Britain would be unable to provide any staff.

Dyer returned to New Zealand, as nothing further could be done until all the governments had reached agreement. New Zealand approval was given on 1 November 1940, with the proviso that the position was to be reviewed at the end of the war. New Zealand agreed to pay 50 per cent of the annual cost, while the office building and the Director's house would be included as part of the general development of the airport, and the associated facilities at Suva Point. Both the United Kingdom and Fiji governments were informed.

It was not until June 1941 that Britain gave formal approval to these proposals, by which time Dyer, and another New Zealand meteorologist, with the consent of the Fiji Government, had been back in Fiji for six months establishing a forecasting service. A third meteorologist followed in September 1941 to assist with the increasing duties.

Dyer was appointed by the Fiji Government as Acting Director of the Fiji

Service, and he was also Senior Meteorological Officer of the RNZAF Meteorological Section in Fiji. He and his assistants were granted honorary commissions in the RNZAF. The main expansion of the Service in Fiji took place after February 1942, when the whole of the New Zealand Meteorological Service was mobilised into the RNZAF.

As a result of persistence, a small but smoothly operating weather forecasting organisation was in place in the South-West Pacific when Japan entered the war, and the Pacific became an operational theatre. In the early stages of the war the governments of both Britain and New Zealand were preoccupied with immediate problems, and were reluctant to allocate resources to projects then considered peripheral to their main concerns. It was just as well therefore, that the New Zealand Meteorological Service persisted in advocating the necessity for a weather forecasting service for military aviation in the South-West Pacific.

Co-operation with the United States

The co-ordinating functions of the International Meteorological Organisation (IMO) necessarily ceased on the outbreak of war. In the South Pacific, where a number of allied nations maintained meteorological services, the need for agreement on the procedures for the exchange of weather information, when such information was classified material, was essential.

In an attempt to bring about uniformity of practice among the Allies, a conference was held in Batavia, Netherlands East Indies, in June 1941. Barnett attended on behalf of New Zealand, and Australia, Malaya, Britain, the United States, and the Netherlands East Indies were represented. Procedures for wireless telegraph transmission in secret cypher of synoptic weather reports and forecasts and the provision of weather information to aircraft were agreed.

The entry of Japan into the war and her rapid advance into the South Pacific, removed from the scene some of the meteorological services which had taken part in the Batavia Conference, but it also brought the United States into the region in strength. There was need for even greater Allied collaboration, with the Americans taking the major role. Collaboration with the Americans, however, was complicated by the presence of two independent weather services, that of the US Navy and the US Army Air Force (USAAF).

In June 1942 American weather personnel arrived in the South Pacific, and a US Navy staff aerological officer was attached to the headquarters of the commander of the South Pacific Forces at Auckland. The USAAF weather service had advance units at scattered bases in the Pacific, and by September the 17th Weather Region was officially established and a regional

control officer, Lt. Col. Floyd B. Wood attached to the headquarters of the US Air Forces in the South Pacific, at Auckland.

In order to overcome lack of uniformity in the methods of encoding and encyphering weather observations, a meeting of representatives of the two US weather services, Australia, and New Zealand, was held in Auckland in December 1942. The question of the best arrangement for US—NZ collaboration was also discussed. The Australians had solved the problem by forming a single directorate of the USAAF and RAAF weather services, under the control of the Director of the Australian Service, with the USAAF Staff Weather Officer as deputy with responsibilities for American personnel and equipment. Although a formalised arrangement of this sort had been suggested for US—NZ co-operation, the Auckland meeting opted for a loose arrangement, depending on frequent informal meetings — sometimes in New Zealand, and sometimes in New Caledonia. The USN and USAAF Headquarters shifted to Noumea when the Japanese southwards advance was halted.

At the end of 1944 American weather units were withdrawn from some of the South Pacific bases, and the 17th Weather Region was amalgamated with the 7th Weather Region (North Pacific) based at Honolulu. This made informal discussion much more difficult.

On a wider field, inter-theatre meetings of the weather services operating in the Pacific south of the equator became an accepted institution. The 1942 Auckland meeting although initially intended to solve a US-NZ problem, in fact became also an inter-theatre meeting. It was followed by further gatherings at Brisbane in June 1943, Sydney March 1944, Manila January 1945, and Melbourne in December 1945. The first meetings were concerned with an overall reduction in the numbers of codes and cyphers used in the area. By 1945, with the end of the war in sight, the problems of post-war co-operation in the South-West Pacific received attention.

At the organisational level there was full collaboration and co-operation in the South and Southwest Pacific areas between the meteorological services of the USN, USAAF, and RNZAF.

Combined Meteorological Committee

Over and above the co-ordinating bodies in the Pacific, already described, there was a Combined Meteorological Committee (CMC) which the Combined Chiefs of Staff in Washington set up in 1942. Its aim was much the same as that of the lower level bodies in the South Pacific, but it had more of a global responsibility. Its decisions were only recommended procedures and not binding. By the time that it held its first meeting in November 1942

the local problems of co-operation in the South Pacific were well in hand.

New Zealand was invited to send a representative to Washington when the idea of a CMC was first mooted. The Meteorological Service was so short of staff at the time that Barnett recommended that, until a New Zealand input was really needed, its interests should be looked after by the RNZAF representative at the Washington Mission.

By December 1942 a meteorologist from either Australia or New Zealand, with a full knowledge of the allied weather organisation in the South Pacific, was needed at CMC. Barnett was unwilling to have the New Zealand viewpoint advanced by Australia, and suggested that Simmers should go to Washington. Simmers had acted as the secretary of the Auckland meeting and had a thorough grasp of the organisational problems.

The CMC operated throughout the war, but by March 1943 the codes and procedures had all been agreed to, and the minor confusions over the relationships, and chains of command, of the various meteorological organisations had all been smoothed out. There was no longer any need for technical representation by New Zealand and the RNZAF staff officer resumed a watching brief for New Zealand's interests. Simmers returned to New Zealand via England, where he was briefed on meteorological operations, research, and training, in the United Kingdom.

Palmer and working level co-operation

The only purpose of all these top level meetings, and the consequent organisational arrangements, was to provide meteorologists, whether in the large central offices or in the scattered units in the forward areas, with the basic observations to enable them to analyse their weather charts and produce operational forecasts. The production of satisfactory forecasts also depended on a knowledge of the principles behind the day to day weather changes, affecting flying operations.

The American meteorologists coming into the South Pacific were at a disadvantage, because of their lack of familiarity with the movement and development of weather systems even in the southern middle latitudes — let alone the southern tropics. It was fortunate, that in 1942 the results of C. E. Palmer's investigations into frontal and air mass analysis in high and middle latitudes of the Southern Hemisphere were published. "Synoptic analysis over the Southern Ocean" was an important advance in the application of Norwegian frontal methods to the Australia-New Zealand region, and was particularly helpful to meteorologists coming fresh to the South-West Pacific.

Palmer had left the Service in 1935 to take up a position as lecturer in

Biology at Victoria University College, Wellington, but rejoined on the outbreak of war — soon turning his attention to tropical meteorology with which New Zealand meteorologists had only limited experience. He began a systematic study of the scattered weather observations from the tropical South Pacific, with a view to compiling a manual to assist forecasters. This was urgently required by both New Zealand and American forecasters.

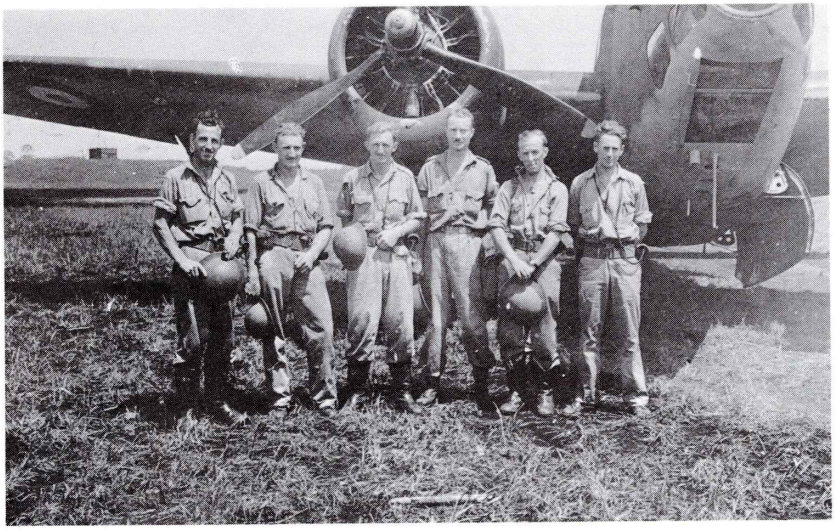
Early in 1943 the University of Chicago began to plan a meteorological institute, sponsored by the USAAF, for research and training in tropical meteorology. Professor C. G. Rossby wanted an experienced tropical meteorologist to start the project, and sounded out Simmers when he was in Washington about the secondment of Palmer to the position for a limited period. There was some hesitation in New Zealand over immediate agreement, because of staff shortages and the uncompleted manual of tropical meteorology.

In the meantime Palmer had done a short tour of duty with an operational squadron in the Pacific to gain practical experience. He was keen to accept the American invitation. In a letter to Col. Wood, USAAF, written while he was at Guadalcanal in the Solomon Islands, he refers to conditions there not being conducive to writing out theories and working up observations, and said that he was going to hand over to Washington the Manual material he had already compiled. Soon after his return to New Zealand he was given twelve months leave of absence from the RNZAF to go as Director to the Institute of Tropical Meteorology at Puerto Rico.

While in the United States Palmer had discussions with the US Weather Bureau meteorologist Jerome Namias on extended range forecasting. The five-day forecasts produced by Namias for the United States had been judged promising, and an improvement on anything previously tried. When Palmer returned to New Zealand after his term in Puerto Rico, he put forward a proposal for a research project into extended range forecasting for the tropical South Pacific. The USAAF had expressed interest and a six month investigation with joint US-NZ participation was mounted in Wellington in 1944.

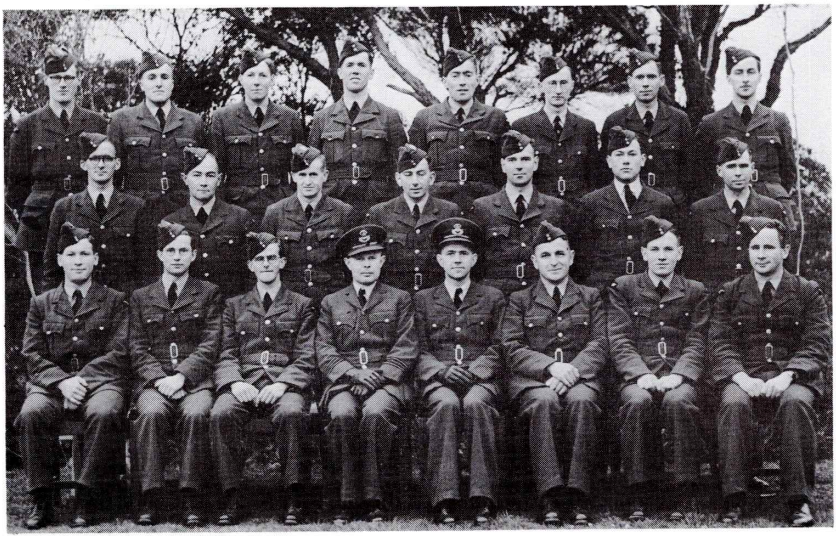
No positive results came from the project, and the methods found useful in middle latitudes were not appropriate for the tropics. However, new methods for analysing tropical weather were developed and later used in the Pacific for producing operational forecasts. From a parochial viewpoint, the main gain was the setting up of a full-time research unit in the Meteorological Service.

Palmer left the Service at the end of the war, going first for a short period to the University of Melbourne as a lecturer in scientific method. From there he went to the Institute of Geophysics at the University of California at Los



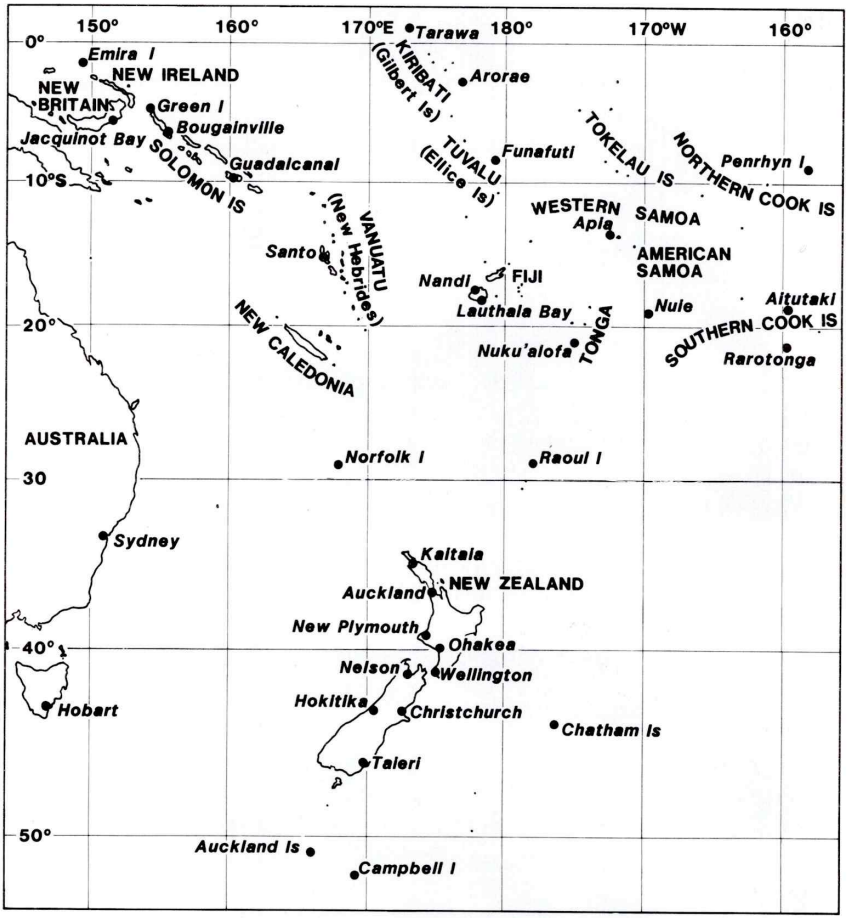
(RNZAF)

Flight Lieut. G. E. Gudsell RNZAF (third from left) and crew of Hudson reconnaissance bomber, Guadalcanal, Solomon Islands 1942. J. F. Gabites third from right.



(N.Z. Met. Serv.)

First course of temporary war-time meteorologists, Kelburn 1942. C. L. Palmer, J. W. Hutchings respectively 4th and 5th from left front row, J. F. de Lisle, 2nd from right front row.



Location map of South-West Pacific.

Angeles, where he remained until his retirement in 1972. The tropics remained one of his main meteorological interests, and in 1953 he set up the UCLA 'Oahu' research project in Hawaii. The group he headed produced the first integrated description of the tropical general circulation in the Pacific and, more or less incidentally, brought the practical advantages of streamline analysis to the attention of practising forecasters the world over.

Palmer had a stimulating influence on the New Zealand Meteorological Service. He was a man with wide intellectual interests, a lively intelligence and an irreverent wit.

Overseas operations as part of the RNZAF

On the mobilisation of the Meteorological Service into the RNZAF, its only overseas units were in Fiji and Western Samoa. By the end of the war meteorological sections had operated in the following sixteen places in the Pacific:

Western Samoa (Apia Observatory),
Fiji (Lauthala Bay, Nandi and Nausori),
Tonga,
Norfolk Island,
New Caledonia,
Espiritu Santo (Palikulu and Segond Channel),
Solomon Islands (Guadalcanal, Halavo, Gouganville, Green Island),
Bismarck Archipeligo (Emirau, Los Negros and Jacquinot Bay)

There were also coast watching stations in the Pacific, and in the sub-Antarctic islands, at which Meteorological Service personnel were stationed, as well as the important station on Raoul Island in the Kermadec Group. Except for the coast watching stations, Raoul Island, and those in Fiji and Western Samoa, all were established to provide a weather forecasting service for RNZAF squadrons. It was considered desirable that with the possible exception of fighter squadrons, all RNZAF squadrons should be supplied with weather information by their own meteorological units. In some instances these RNZAF forecasting sections made use of the American communications facilities.

Western Samoa

Although the Service finally based its Pacific operations on the British colony of Fiji, it still maintained an important station in the New Zealand trust territory of Western Samoa. The observatory on Mulinu'u Peninsula near Apia had been taken over from German control when the New Zealand mandate of the territory was confirmed by the League of Nations in 1920.

The observatory had been founded in 1902, by the Society of Natural Sciences of Göttingen, for the purpose of taking observations simultaneously with those of an Antarctic expedition. It was made permanent, and became an important geophysical and meteorological station in which there was international interest. Its publications from the early days, contains papers by meteorologists who subsequently became prominent in European science.

New Zealand administered the observatory through a Samoa Meteorological Observatory Board, until it was taken over by the DSIR in 1928. The provision of adequate funds was always a struggle and without grants from the British Admiralty, and generous contributions from the Carnegie Institution and the Rockefeller Foundation in the USA, the observatory could not have functioned. In the small New Zealand budget for science, the claims of the Apia observatory did not rank very high.

In 1922-23 Apia became the centre for the collection of weather reports in the South Pacific, because of Royal Navy interest. By 1924 New Zealand received twice daily radio weather reports from Apia, Papeete, Rarotonga, Suva, Vila, and Nukualofa. Bates said at the time that 'so far these have shown no relation to our weather conditions'. A continuous programme of pilot balloon observations of upper winds was carried out by Andrew Thomson, the Director, long before regular observations were made in New Zealand.

During the depression years of the early 1930s the New Zealand contribution to the observatory fell to £280 a year and was in danger of being cut altogether. Kidson was apprehensive that the loss of this grant would stop the weather reports from Apia during the second Polar Year of 1932-33. He wrote to Lord Rutherford, and to Sir Henry Lyons the Director of the Science Museum in London, asking them to attempt to persuade Downie Stewart, the New Zealand Minister of Finance who was in London at the time, to continue the Government subsidy.

The Department of Terrestrial Magnetism of the Carnegie Institution expressed dissatisfaction with the conditions at the observatory, and with the way that New Zealand provided information on the funding. There would probably have been no American grant if the smallness of New Zealand's own contribution had been known. However, as Professor Coleridge Farr of Canterbury University College pointed out to the DSIR Advisory Council, the complete maintenance of the observatory was too great a burden for New Zealand alone. Because of the international importance of the geophysical and meteorological observations made at Apia, the Council was justified in seeking help in funding from the Northern Hemisphere. He recommended

a ten year plan for the adequate financing of the observatory, but there is no record of any follow-up to his suggestions.

With the growth of trans-ocean civil aviation, meteorology assumed greater importance in the work of the station. On the recommendation of the DSIR Observatories Committee, the control of the Apia observatory was transferred to the Meteorological Service on 1 September 1939. This had the advantage of facilitating the regular interchange of staff between New Zealand and Apia, and thus providing a pool of officers with some tropical experience.

In due course the ex-patriate observatory staff were mobilised into the RNZAF, and constituted a self contained unit. The weather forecasting duties were never onerous although in the later stages of the war RNZAF transport aircraft passed through Western Samoa at regular intervals.

Throughout the war the staff carried out routine observatory duties in meteorology, seismology, and terrestrial magnetism. Apia became an important centre for the collection and dissemination of weather reports from the eastern area of the South Pacific.

Fiji

With the entry of the United States into the war, American servicemen and equipment poured into Fiji. Airfields were built in Nandi and Nausori, and US Navy as well as Pan American flying boats used the facilities at Lauthala Bay, Suva. In September 1942 Dyer pointed out the problems introduced by the operation in Fiji of four semi-independent meteorological services: the US Army Air Force at Nandi, the US Navy at Suva, Pan American Airways at Suva, and the RNZAF. He suggested that the US Army Air Force assume weather forecasting responsibility for US aircraft operating through Nandi; Pan American requirements be met by that Company's meteorologists; the US Navy meteorologists be attached to the Fiji Meteorological Service and supply forecasts for the Navy aircraft; RNZAF meteorologists in Suva should be responsible for all RNZAF aircraft whether operating from Suva, Nandi, or Nausori, and also for the observational networks.

Dyer made a further appeal to New Zealand in October 1942, for the formulation of a definite policy of co-operation with the various US meteorological services and a demarcation of responsibilities. This was by no means a simple problem, and is considered in detail later. In the event, his suggestions became the basis of co-operation at the working level in Fiji, even if not embodied in formal agreements.

The excellent relations that Dyer established with the US Navy in Suva were turned to good account. A fine office building in permanent materials

was constructed at Lauthala Bay. Commander Dannis of the US Navy secured the agreement of the RNZAF Group Captain for the erection of the new meteorological office into which RNZAF staff moved in February 1943. This building is still used by the Fiji Meteorological Service.

The Lauthala Bay Office operated a 24-hour service for RNZAF local operations, for transport aircraft, and for the civilian population — especially in the matter of hurricane warnings. In 1942 New Zealand meteorologists were attached to Nandi to provide forecasts for the RNZAF aircraft passing through. When Nausori became the base for an RNZAF Bomber Reconnaissance squadron a separate meteorological unit was established there. Communication difficulties prevented Lauthala Bay from providing a weather forecasting service for Nandi and Nausori.

Suva became the collection and dissemination centre for weather reports for the Western Pacific region. It was also used as a training ground for New Zealand meteorologists to gain some experience in tropical meteorology, before being posted to the forward areas in the New Hebrides and the Solomon Islands.

Tonga

Prior to the war Nukualofa had for many years been the collecting centre for weather reports from the various islands in the Tongan Group. The reporting network was then under the direction of the officer in charge of the radio station. The RNZAF meteorological unit was set up, because of the 1942 request by No. 15 Squadron of the RNZAF for a meteorologist to liaise with the USAAF weather unit on the Island.

For a brief period in 1943 a detached flying boat unit from Lauthala Bay operated from the US Navy base at Nukualofa, and a forecaster was attached. During the following year while an RNZAF reconnaissance squadron was based on Tongatabu, the meteorological unit was increased in size. An army RDF radar set was installed for upper wind observations and a full observing programme was carried out.

Norfolk Island

As Norfolk Island is a territory of the Commonwealth of Australia, an Australian meteorological observer was stationed on the Island in March 1939 to provide surface and pilot balloon upper wind observations. The importance of meteorological information from Norfolk Island is, however, much greater for New Zealand operations than Australian.

By 1942 an airstrip had been constructed, and was used by RNZAF aircraft

in transit from New Zealand to New Caledonia. With the prospect of an RNZAF squadron being based on the Island, the Australians requested the New Zealand Meteorological Service to take over from their civilian observer, who would be unable to give an extended service.

In January 1943 Flt. Lt. I. E. M. Watts and an RNZAF section took over from Thornton, the Australian observer, and New Zealand provided the necessary weather forecasting and observing services until after the war. In August 1943 radiosonde receiving equipment was obtained on loan from the US Navy, while upper wind measurements were made with an army GL Mk II radar set.

Towards the end of the war there were discussions between Australia and New Zealand on the future of the station, which would continue to be an important link in the Pacific weather observation network, especially for New Zealand. While the Commonwealth Meteorological Bureau accepted in principle the responsibility for the continuation of the station, there was a reluctance at the end of the war to conclude an agreement on the transfer of meteorological and communications equipment from New Zealand to Australian ownership. The Commonwealth Bureau was short of trained staff, as was New Zealand, and the manning of Norfolk did not feature very high in its list of priorities. It was not until 1948 that the New Zealand Meteorological Service was able to hand over to the Australians.

New Caledonia

The RNZAF meteorological branch became involved in New Caledonia in July 1942, at a time when the situation there was confused. The Australians were withdrawing their forces, and American navy and army units together with No. 9 BR Squadron RNZAF had moved in. The US Navy aerological unit at Ile Nou in the south of the Island was the only source of meteorological information. It was understaffed, and could not satisfactorily service the RNZAF squadron at Plaine de Gaiacs over 100 miles away. It therefore asked for help on a temporary basis from New Zealand. Plans for the overall co-ordination of the Allied meteorological facilities in the Pacific were then being worked out.

Flying Officer J. H. Croxton was posted from Suva to New Caledonia. Although he was formally attached to the New Zealand unit at Plaine de Gaiacs he was to operate from Ile Nou in close co-operation with the US Navy unit. Besides assisting in the weather forecasting duties and general organisation, he was to improve the quality of the weather reports from the outlying stations.

For the next four months Croxton provided a useful liaison between the American and New Zealand units, and helped clarify the confused state of the meteorological facilities in New Caledonia.

However necessary this work was for the overall state of the weather services in the area, it did not fully meet the requirements of the RNZAF squadron. It was therefore decided in Wellington to send another RNZAF forecasting unit to Plaine de Gaiacs. In the meantime a USAAF weather unit moved into the area and gave some service to No. 9 Squadron. To avoid duplication of effort it was then decided to form a combined US—NZ meteorological section. In this case allied co-operation did not work, and differences of opinion at the working level led to a splitting of resources. The RNZAF unit worked independently until it moved north with the squadron in March 1943.

Operations in the forward areas

New Hebrides and Solomon Islands

The first RNZAF operational unit to leave New Zealand to operate with the American forces in the forward areas, was No. 3 BR Squadron. It flew to Santo in the New Hebrides in October 1942, and was accompanied by a small meteorological unit consisting of Flt. Lt. J. F. Gabites, an NCO, and two airmen. They arrived to find that all weather forecasts for operations from Santo were supplied by a US Navy aerological unit aboard the aircraft from *Curtiss*. When the 11th Bombardment Group of US aircraft arrived on Santo, a second navy aerological unit was set up on shore.

A combined US Navy—NZ meteorological section had been suggested, but accomodation difficulties had prevented this and Gabites started independently to provide a weather service for the RNZAF squadron. The arrival later of USAAF weather staff in Santo added to the complications. They were instructed, as a temporary measure, to work with Gabites and be under his technical direction.

By November a combined USN, USAAF, and RNZAF base weather station was established and this, together with the unit still operating from the *Curtiss*, was able to cope with the meteorological requirements of the allied forces in the area.

On 24 November a flight from No. 3 BR Squadron RNZAF moved to Guadalcanal in the Solomon Islands, followed a week later by the remainder of the squadron. Gabites also moved north, and set up a one-man weather forecasting unit. Poor communications prevented the reception of weather reports. The only information came from an intensive study of the observa-

tions made by air crew while on patrol, and from the daily coded weather chart broadcast from Wellington.

Gabites flew each afternoon as observer-gunner to acquaint himself better with the weather encountered in the area and was several times in action. From his own observations, and his debriefing of the aircrews, he was able to derive empirical rules and give a successful forecasting service to the Squadron. He was repatriated to New Zealand in February suffering from malaria. For his outstanding efforts under trying conditions, Gabites was later mentioned in despatches.

The practical difficulties of running a combined US—NZ weather centre in Santo, and the imminent arrival of a second RNZAF squadron from Plaine de Gaiacs in New Caledonia, led to the establishment of a separate RNZAF weather forecasting section. The RNZAF meteorological units at Santo and Guadalcanal operated until the end of hostilities in the Pacific. The normal practice of staffing the New Zealand units, was to send forecasters and observers to Fiji to gain experience of tropical weather. They were interchanged between Santo and Guadalcanal to enlarge this experience. The tour of duty in the area was restricted to six months.

As the allied military position in the South Pacific was consolidated, an RNZAF base depot was set up at Santo. There was an increase in transport aircraft traffic. The main duties at Santo and Guadalcanal continued to be the provision of weather forecasts to these flights and those of the BR squadrons. Both offices increased in size and they retained close contact.

In October 1943 an RNZAF flying boat squadron was posted to Segond Channel on Espiritu Santo, where it stayed for two months before being transferred to Halavo in the Solomons. The US Navy supplied weather information during this period, but when the Squadron moved an RNZAF forecasting unit was established at Halavo and remained in operation until the withdrawal of the squadron in August 1945.

A second RNZAF flying boat squadron operated from Segond Channel from October 1944 with its own meteorological section.

Northern Solomon Islands and Bismarck Archipeligo

In April 1944 No. 2 BR Squadron RNZAF, moved forward to Bougainville Island in the northern Solomons. The No.1 RNZAF Islands Group then decided that the weather services for the squadron would be provided by the US units already established there. This was done to avoid duplication of effort but was not popular with either the RNZAF aircrew or the New Zealand meteorologists.

There had been criticism by the RNZAF, not always justified, of the weather forecasts provided by the Americans. In spite of all attempts at standardisation, there were differences in presentation, and the RNZAF aircrew had greater confidence in their own technical advisors. It is also true, that there were some New Zealand meteorologists in the field with more experience and greater expertise in the meteorology of the typical South-West Pacific than their allied counterparts.

The United States forces were present in overwhelming numbers, and the New Zealand effort in the Pacific was dependent in many ways on American logistical support. Barnett had requested that an RNZAF meteorologist and staff should be attached to any base from which RNZAF aircraft operated. This had to be approved at the highest level and the RNZAF directorate had not found it expedient to raise the matter at allied air forces meetings.

The problem was circumvented by the formation of a self-contained RNZAF task force whose headquarters were set up at Bougainville in the northern Solomons on 1 September 1944. An RNZAF meteorological section joined the force in the following month. Gabites was appointed officer in charge with the position of Staff Officer Meteorology. His duties were to give a local weather forecasting service and co-ordinate the RNZAF meteorological activities in the region. Forecasting units were established at Green Island and Emira in October, Los Negros in December, and at Jacquinot Bay in May 1945.

The planned mobility of the RNZAF task force did not eventuate, and in fact the operational importance of the weather in many areas was not great. Because of the disposition of their units it was sometimes more convenient for the RNZAF aircrews to use the USAAF weather service.

In November 1944 it was suggested by the task force headquarters that all meteorological units be withdrawn, as their existing duties could satisfactorily be performed by the Americans. The RNZAF headquarters in New Zealand considered this to be premature. A change in the location of the RNZAF meteorological section on Bougainville and a concentration on upper air analysis meant that it began to operate as an effective unit for the transit aircraft. For the remaining seven months of its existence the unit was fully occupied.

The outlying sections had mixed usefulness: that at Emira in the northern Bismarck Archipeligo provided the most successful service. It coped with the requirements of the New Zealand and Australian transit aircraft. It also gave a necessary weather forecasting service to the BR squadrons operating on bombing missions to New Ireland. The importance of weather was much greater there than it had been at Bougainville.

In some of the other task force bases, the New Zealand meteorologists collaborated with either the RAAF or the USAAF units. The insistence of the New Zealand aircrews for service by their own meteorological units, though sometimes based on prejudice, was an indication of the general confidence they placed in the RNZAF weather units in the South Pacific.

Coast watching stations

The Cape Expedition — Auckland and Campbell Islands

Shortly before the outbreak of war the Chiefs of Staff Committee of the Organisation for National Security (ONS) approved the visits to the Auckland and Campbell Islands of a naval vessel whenever the opportunity offered. It was recognised that those sub-Antarctic islands quite near New Zealand (the Auckland Islands were only 480 km away) could give shelter to enemy raiders or their supply ships. When German raiders did operate in the waters around New Zealand in 1940, and sank four ships, it added weight to the efforts to ensure that the sub-Antarctic islands were not used by Germany.

Although both HMNZS *Leander* and HMNZS *Achilles* visited the islands they could ill be spared for the purpose. Also the probability of the visit of a NZ Navy vessel coinciding with that of an enemy raider was not great. The War Cabinet therefore approved an ONS proposal that observation parties and radio stations should be established on Campbell Island and on the Auckland Islands. The Navy Office was to assist with shipping and be responsible for the operational control and the Public Works Department for recruiting personnel and procuring stores and provisions.

Three coast watching stations were to be established; No. 1 at Port Ross and No. 2 at Carnley Harbour, in the Auckland Islands; and No. 3 at Perseverance Harbour on Campbell Island. In order to have a means of evacuation if a German raider did visit the Auckland Islands, the MV *Ranui* of 57 tons was used for periodical coast patrols and servicing, and lay up in an inlet on the east coast of Auckland Island serving as a fourth station. The party on Campbell Island did not have such a back-up.

The project became known as the Cape Expedition and the advance party left Wellington on 5 March 1941. The three camps were established and manned, the term of service for the personnel being twelve months. Meteorological Service staff were included in the parties from the third year onwards. In the first year a weather report was sent out in special code once a week, radio traffic being kept to a minimum. However, the frequency was stepped up to three reports a day from the second year onwards.

The main purpose of the stations in their four and a half years of operation was to report on any ships visiting the islands and to continue reporting

without being detected. No enemy ships were ever sighted and there was never any call to adopt the ruses suggested in the Navy Department's 'most secret' orders issued to the first party.

> As the enemy might arrive soon after your arrival, it is of the utmost importance to get your W/T working as soon as possible. If he arrives while the *Tagua* is still in company with you, you must attempt to conceal the real object of the expedition, if necessary allowing him to capture ratings with the *Tagua*, or pretend she is there on a fishing trip; or adopt any stratagem you think will throw him off the real object of the party.

In the first two years the expedition members were given no military status, and it is probably just as well that there were no enemy sightings. In the third year all members were attested by the army, each being given the rank of private.

In October 1944 when the question of closing down the stations was being considered, Barnett pleaded for the continuation of Campbell Island as a permanent meteorological station. This was eventually approved and when the Auckland Island expedition members were withdrawn in June 1945, the Campbell Island men remained. They were demobilised in October and the station reverted to civilian status.

This was the end of the Cape Expedition whose most valuable result for the Meteorological Service was the establishment of a permanent weather station in the sub-Antarctic. Otherwise this would have been extremely difficult to achieve.

In the Pacific

The ONS gave attention to setting up coast watching stations on the Pacific Islands as well as on the sub-Antarctic islands. By the time that Japan entered the war in December 1941, a coast watching system had been established in the outlying islands of the Fiji Group, the Gilbert and Ellice Islands, and in the Northern and Lower Cook Islands. The RNZN had altogether the oversight of fifty-eight coast watching stations.

The radio operators were given a course at Kelburn in making surface weather observations before being posted to their island stations. Special codes were used to encypher the reports before transmission. No Meteorological Service staff were seconded for Pacific coast watching duties.

In the Gilbert and Ellice Islands twenty-two New Zealand soldiers and fifteen civilian Post Office employees manned the stations. All were captured and half the radio operators with their army colleagues were executed by the Japanese in October 1942. Other coast watchers had to contend with

the hazards of tropical cyclones on coral atolls. In February 1942 the island of Suwarrow in the Northern Cook Group was struck by a cyclone. Seas washed right over the island and the coast watching party escaped only by retreating to the treetops.

The coast watchers provided weather reports which were valuable additions to the naturally data-sparse Pacific Islands network.

Raoul Island

In 1936-37, when the Meteorological Committee of the ONS was discussing the extension of the weather reporting network in the South-West Pacific, it was inevitable that the Kermadec Group be considered. Raoul Island about 600 miles north-east of Auckland was potentially a valuable site for observations and also for radio navigation aids for aviation. Moreover it was New Zealand territory having been formally annexed in 1886. There were, however, considerable logistic problems in establishing a station on an isolated island with an exposed anchorage and difficult landing conditions.

An aeradio committee of the ONS was given the task of considering the problem. It recommended to Cabinet that there should be an investigation on the site. The reasons for a permanent station on Raoul Island were given as:

1. To provide better weather forecasts for New Zealand.
   (It was suggested that the cyclone of February 1936 would have been more accurately forecast if reports from Raoul Island had been available. The Meteorological Service had received widespread criticism for not giving earlier warnings of this storm.)
2. To provide weather reports for trans-ocean air services and for shipping.
3. To provide navigational radio beacons for Pacific air services.
4. In time of war to provide the above services for the RNZAF and the Navy.

The Cabinet approved the recommendations and in July 1937 a survey party of six left Wellington on GMV *Maui Pomare* for Raoul Island. Besides reporting on the suitability of the island for a radio and meteorological station they were to send back daily weather reports for evaluation.

It is not the place here to trace the story of the previous attempts to colonise the island and the tangled claims, valid and invalid, to the ownership of the land on Raoul Island. A full account of the history has yet to be written. The survey party found seven men on the island. Two were taken on as general assistants while the rest, who were would-be settlers in a poor and dispirited condition, were shipped back to New Zealand in the *Maui Pomare*.

The survey found that a permanent station capable of fulfilling the envisaged purpose would be possible but costly. There was nowhere to construct an emergency aircraft landing strip. Servicing of a station would have to be by sea on an exposed coast, and was hazardous unless landing equipment and an access road to the camp was provided.

The Meteorological Service found that the weather reports were useful, while Pan American Airways, the RNZAF and the RNZN all supported the establishment of a permanent station. The aeradio committee recommended that the survey party remain on the island and start work preparatory to building a base camp and also keep the weather reports going. This was approved and the key members of the party were not withdrawn until April 1938. The New Zealand Government had assumed all the freehold titles to land on the island and the two original settlers left on Christmas Day 1937.

Until the work on roads, buildings and landing facilities started in 1939, the landing of supplies and mail continued to be dangerous. Two members of early parties were drowned. Meteorological reports continued, and early in the war, coast watching was added to the duties of the staff.

Meteorological services to the army

During the first World war the British army had called on meteorologists for estimates of the upper winds that the artillery must take into account in its operations. In May 1939 the GOC of the New Zealand military forces pointed out to the Secretary of the DSIR that in the event of war this type of information would be needed on a daily basis in New Zealand both for coastal and field artillery. He suggested that Meteorological Service staff should be enlisted in the territorial army to form meteorological units for field operations.

This could not be done because of the small number of trained meteorologists available but Kidson proposed a compromise. The Meteorological Service would train army personnel for a mobile section and provide the wind information for coastal artillery from its offices in Auckland, Wellington and Christchurch. By June 1941 the three field regiments of the New Zealand Artillery had mobile meteorological sections manned by artillery personnel trained by the Meteorological Service.

Britain had in the mean time changed to a system of much greater co-operation between its artillery and air forces. New Zealand followed suit and decided that the mobile meteorological sections for artillery duties should belong to the RNZAF meteorological branch. This produced a more efficient use of the available meteorological staff.

In August 1942 the army requested a mobile meteorological section to

accompany its Third Division which was to proceed overseas. An RNZAF detachment of four was formed and embarked for New Caledonia in November 1942. There it remained for nine months. The unit had negligible duties as the division was engaged in training for future active service in the Solomon Islands. The section was assigned to assist the RNZAF meteorological unit at Plaine de Gaiacs and supplied the army with wind information when it was needed. This was a demoralising state of affairs as in practice the section had few definite duties.

When the division moved to the Solomons in August 1943 the RNZAF meteorological section did not accompany it. The wind information was supplied to the division by survey troop personnel trained by the meteorological officer.

The RNZAF section was withdrawn in January 1944 after an unsatisfactory tour of duty.

Advances in observational techniques

At the beginning of the war, weather map analysis of the structure of weather systems showed conditions at the earth's surface only. It followed the principles of air mass and frontal analysis developed by the Norwegians and adapted to the Australia-New Zealand area by Kidson and Holmboe. The work of Palmer on the meteorology of the southern oceans enabled a more systematic application of the Norwegian methods.

Prior to 1942 most data on the wind flow above the surface came from the tracking by optical theodolite of pilot balloons. Such observations had been made in New Zealand since 1929 but were limited to fine weather conditions. The newly developed military radars were soon applied to following meteorological balloons fitted with a suitable reflecting target. Experiments began in 1942 at Ohakea and early in 1943 observations made with British Army radar RDF GL Mk II gave upper winds which were in most cases as accurate as those found by theodolite. The Ministry of Supply in Britain reported similar conclusions at about the same time.

Eventually regular upper wind observations were made with army GL radar sets at Suva, Tonga, Norfolk Island, Auckland and Ohakea. It was then possible to construct upper wind flow charts using data from the radar flights, aircraft observations and pilot balloons.

In 1942 the New Zealand Radio Development Laboratory under the direction of C. Watson-Munro was asked by the American forces to design a radar for the detection of enemy aircraft. Work was carried out on the project in both Wellington and Christchurch. Operational trials of the first set were held at Auckland in 1944 using aircraft and meteorological balloons as targets.

Four of these ME 7 radar sets were made in New Zealand but did not become available to the Meteorological Service until after the war.

Regular temperature and humidity measurements in the upper atmosphere were not possible until the US Navy began radiosonde observations in Auckland in 1942. The equipment was taken over by New Zealand and by the end of the war the meteorological branch of the RNZAF operated American supplied radiosonde equipment at Suva, Santo, Norfolk Island, Hokitika and Taieri.

Prior to the introduction of the radiosonde, spasmodic temperature and humidity observations had come from special meteorological flights in RNZAF aircraft. Larsen began these in Wigram in 1937 acting as observer in open cockpit aircraft with thermometers strapped to the wing struts. In 1938-39, 125 flights to an average height of 16,000 feet were made at Wigram. Similar flights were also made at Nelson, Rongotai and Waipapakauri. Two US meteorographs were later obtained for flights from Wigram and Rongotai. They gave an autographic record in place of the visual observations.

Repairs to instruments posed a problem for many years. Initially the services of the No. 1 Repair Depot RNZAF and of the DSIR Dominion Physical Laboratory were used. This *ad hoc* arrangement was not satisfactory but it was not until the latter years of the war that two instrument mechanics were appointed to the Kelburn Head Office of the Service. An RNZAF wireless mechanic was also appointed to deal with field inspections. This was the beginning of the Meteorological Service's instrument section.

5

Post-war organisation and administration

In mid-1945, with the end of the war in sight, it was time to consider the return of the Meteorological Service to civilian status. The possibilities were either to rejoin the DSIR, or to continue with aviation interests but in a civilian capacity.

Since 1939 the demands of military and civilian aviation had almost totally determined the structure and operation of the Service. Advances in the science of meteorology had come about because weather forecasts were required by aeroplanes. Military expediency had led to the wide use of radar for upper wind measurement, and of radiosounding techniques for the measurement of upper air temperatures and humidities. In fact the science of meteorology saw many gains from its close ties with aviation.

The question was whether such a close identification would be appropriate for a New Zealand civilian organisation. Civil aviation authorities appeared to have no doubts about the matter: they had attempted previously to gain administrative control of the Service and once again floated the suggestion. They proposed that the meteorological branch of the RNZAF be immediately demobilised and transferred to the civil aviation branch of the Air Department.

This brought a strong reaction from Barnett, firstly on the narrow interpretation by civil aviation of the aims of a meteorological service for whom aviation was only one client among many, and secondly on the folly of demobilisation before the end of the war which would result in the loss of two-thirds of the staff.

He suggested that the most satisfactory arrangement after the war would be to attach the Service to some appropriate government department as an independent branch, and the Air Department was probably the most likely choice. Nothing more was heard of the suggestion which had the effect of hastening consideration of plans for a peace-time organisation.

With the end of hostilities in August 1945, most of the temporary staff wanted to be demobilised as quickly as possible. Few accepted the offer to make a career in meteorology, and between the end of August 1945 and

March 1946 total staff numbers dropped from 335 to 182. In turn this caused great difficulties for maintaining a civilian weather service.

At the end of the war the Service faced two urgent questions: what kind of administrative control would it be subject to, and what level of support would it be required to provide in the Pacific? The question of administrative control was taken up at a Cabinet meeting on 3 July 1946 when the DSIR and Air Department were instructed to submit a report on the future control of the Meteorological Service. The two departments recommended that:

1. The Meteorological Office should be an independent branch of the Air Department, and continue as the sole authority for providing the meteorological services required for the armed services, civil aviation, government departments, local bodies and the general public.
2. The Secretary of DSIR should always be consulted on matters of meteorological research and have the opportunity of examining and reporting on meteorological research projects.
3. Representatives of DSIR, Marine, and Agriculture Departments, the director of Civil Aviation, and the Chief of Air Staff should have the opportunity of discussing and commenting on the Annual Report to Parliament of the director of the Meteorological Office.

These recommendations were approved by Cabinet on 23 January 1947, the first one effectively determining the administrative framework under which the Service now operates.

The choice of appropriate administrative body to control a state meteorological service is usually a matter of compromise. A meteorological service provides for a wide variety of clients and should also have an active atmospheric research component. In New Zealand, as in most other countries, it is too small to be a viable separate administrative unit. It was probably inescapable at the time that aviation interests, which had been the main reason for the growth of the New Zealand Meteorological Service, would have some part in its control.

Importantly, the recommendations recognised both a need for the independence of the Service, and its wider responsibilities. The suggestion of the formal involvment of the Secretary for the DSIR in matters of meteorological research was probably an attempt to retain some connection between the two organisations, and although it was never implemented, informal links remained strong. The third recommendation, which gave a large number of bodies the right to comment on Meteorological Service activities, was never acted on.

Meteorological services for the South-West Pacific

The agreement between Britain, Fiji, and New Zealand on the operation of

the Fiji meteorological service was due to end six months after the end of hostilities. To assess the need for post-war aviation support services, British civil aviation authorities in August 1945 requested the governments of Britain, Australia, and New Zealand to consider what facilities, including weather services, were needed in the South-West Pacific.

Air Commodore Nevill (later Sir Arthur Nevill) the Vice Chief of Air Staff, pointed out in a planning paper that New Zealand would have to keep the RNZAF bases in the Pacific until December 1945. Because an abrupt withdrawal of American facilities in the area would cause difficulties, he suggested that the United States be asked as a temporary measure to leave the minimum equipment needed for the continuation of future aviation. Bases were necessary in territories belonging to France, Fiji, the Western Pacific High Commission (a British responsibility), U.S.A., Australia, and New Zealand. Nevill also suggested that the Colonial Office in Britain should establish a Directorate of Civil Aviation in Fiji which could rely on Australia and New Zealand for technical assistance. Barnett prepared a paper on the weather forecasting facilities needed at Lauthala Bay in Fiji and the reporting network to support them.

In December 1945 an inter-regional conference was held in Melbourne and it was agreed that nations should look after the meteorological services in their own territories. However Britain had not indicated its plans for the Pacific, and New Zealand and Australia were unsure whether their responsibilities would increase to cover British territories. They were reluctant for this to happen as demobilisation had meant many staff losses.

The New Zealand position had already been pointed out to Britain by the Governor of Fiji, and the Fiji Government had independently advertised for both weather forecasting and observing staff. Despite its knowledge of New Zealand's shortage of meteorological staff, in January 1946 Britain announced that it had decided not to include Fiji in its colonial meteorological service and hoped that Australia and New Zealand would agree to carry on the meteorological services in the British Pacific territories. It was clear that the South-West Pacific would have to fend for itself.

South Pacific Air Transport Council

The withdrawal of units of the American, Australian, and New Zealand armed forces by early 1946 reduced the weather reporting network in the South Pacific to a level which adversely affected the servicing of aviation. It was therefore a matter of self-interest for Australia and New Zealand to safeguard civil aviation and meteorological services in the area.

At a conference in Wellington in March 1946, representatives of Britain,

Australia, Fiji, Canada, the Western Pacific High Commission, and New Zealand, set up a South Pacific Air Transport Council (SPATC) to plan and organise the development of civil aviation air routes across the Pacific. The SPATC had standing committees in air navigation and ground organisation, and in meteorology. The latter was responsible to the Council for making recommendations on all technical matters relating to the organisation and co-ordination of meteorological facilities in the South Pacific.

New Zealand accepted responsibility for the organisation and technical control of the aviation meteorological services east of longitude 170 ° E, and Australia west of 170 ° E. The American military airfield at Nandi, in Fiji, was chosen as the staging post for air routes. It, and not Lauthala Bay, became the weather forecasting centre for Commonwealth territories in the South Pacific.

The SPATC functioned for over 30 years, being funded by grants from the member governments and more recently also from air navigation charges to the airlines operating in the area. It enabled a surface and upper weather reporting network to be maintained, and led to the eventual establishment of separate meteorological services in newly independent Island nations. Part of these Island meteorological activities however came to have only a tenuous connection with aviation, and because of this the aviation industry considered that it was inappropriate to be charged for activities which did not directly benefit aviation. This contributed to the demise of the SPATC, which had played a valuable part in establishing the civil air routes which criss-cross the Pacific.

The New Zealand Meteorological Service was desperately short of staff for many years after the war. This was made more difficult by having to provide weather forecasters for a large office at Nandi, technical officers for the Island territories and for New Zealand's own outlying islands. At times it was impossible to find enough professional meteorologists from New Zealand to fill the posts in Fiji and staff had to be sought on secondment from Britain.

Despite these strains the Service did benefit from this wide area of responsibility in the South-West Pacific area. It was forced to become flexible and at the same time a whole generation of meteorologists and technical officers acquired firsthand knowledge of tropical meteorology.

Recruiting difficulties

Besides losing most of the temporary staff early in 1946, a number of career meteorologists also left New Zealand to go to overseas services or universities. The loss of Palmer as already noted, was a blow to research in the Service

and this was weakened still further by I. E. M. Watts and C. S. Ramage going to the meteorological branch of the British Colonial Service and Dr C. J. Seelye to the Department of Mathematics at Victoria University College, Wellington.

At the time of the transfer to the Air Department there were only 32 professional officers to fill 48 positions, and 123 observers for 139 positions. The number of meteorologists was only slightly greater than it had been in 1939 but the support staff had grown fourfold. Branches in the Solomon Islands, the New Hebrides, and New Caledonia were closed down, and staff numbers reduced in the stations in Fiji, Tonga, Western Samoa and Norfolk Island. Within New Zealand itself there were reductions in the number of stations with a weather forecasting capability.

In 1937 Kidson had complained about the lack of a source of qualified meteorologists in New Zealand, but had been able to recruit high calibre university graduates to his staff. Attempts to recruit university graduates in the immediate post-war years however were largely unsuccessful. But even with a reduced staff, the services had to be maintained to a growing aviation industry as well as to agriculture, electric power generation, and large public works construction projects.

The inevitable result was that the organisation was almost totally engaged in attending to its client groups while research work was neglected. Although the necessity for research was not lost sight of, pressures meant there was little alternative but to concentrate on the provision of services. Young graduates considering a career in meteorology were not encouraged by seeing well qualified meteorologists having to spend all their time on operational duties — generally involving shift work — because of this staff pressure.

At the time there was provision on paper for all professional staff to spend one quarter of their time on research projects, and a notional research section of two meteorologists and two observers. In practice there was no research section and very little research time for the operational meteorologists. Throughout the 1950s the number of available professional officer positions was never filled, and the inability of the Service to recruit enough graduates was regularly mentioned in the Director's annual report to Parliament.

J. W. Hutchings, who had been one of Palmer's assistants, was appointed in 1948 as the first professional research officer. He had no support staff and was also required to give the 3-4 month introductory course for new trainee meteorologists.

In spite of the staff shortages the importance of post-graduate training in meteorology was used as a way of raising scientific standards and making the Meteorological Service a more attractive prospect for graduates in

mathematics and physics. Gabites was awarded a Commonwealth Fund Service Fellowship in 1948 and went to the Massachusetts Institute of Technology (MIT) for his advanced study. E. H. Howell, a senior forecaster, was granted a Rehabilitation Bursary which he took up in the Department of Meteorology at the Imperial College of Science and Technology, London.

The loss for two years of these senior officers, and the poor results from recruiting, caused the Service to advertise for meteorologists in Britain. H. W. Hill, an experienced synoptic meteorologist joined the Service in this way, and went directly to Nandi in 1950. He actively participated in weather forecasting for forty-five years and 'his unbounded enthusiasm for meteorology flowed over into his written and spoken weather forecasts and into his many (published) papers . . .' After three years he transferred to Kelburn.

Gabites and Howell both returned to New Zealand with doctorates in 1951. Gabites was appointed to take charge of research, and a detached building which also acted as a seminar and training room was built to house the new section. He started a regular series of scientific seminars in 1951, but as this catered only for the Wellington staff the coverage was extended to the branch offices — by holding annual scientific conferences for professional officers starting in 1952.

Howell was appointed as officer in charge of the general forecasting office Kelburn on his return, but died the following year.

Changes in organisational control

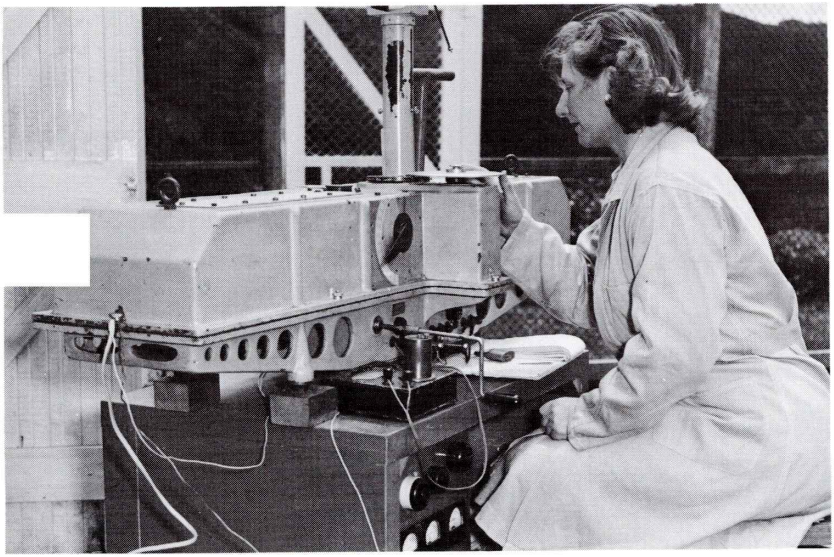
During the 1950s and 1960s the Meteorological Service continued as a semi-autonomous branch of the Air Department. There was freedom within the normal budgetary constraints to organise its own technical resources. This association with the Air Department established in 1947, was by Cabinet directive, and not formally by an Act of Parliament. However in 1964 the passing of the Civil Aviation Act meant the Service became one component of a new Civil Aviation Department. Its functions did not change although they were now clearly identified. It was required to;

(a) provide a meteorological service for the benefit of all sections of the community,
(b) promote the advancement of the science of meteorology, and
(c) advise the Minister and Government Departments on all matters relating to meteorology.

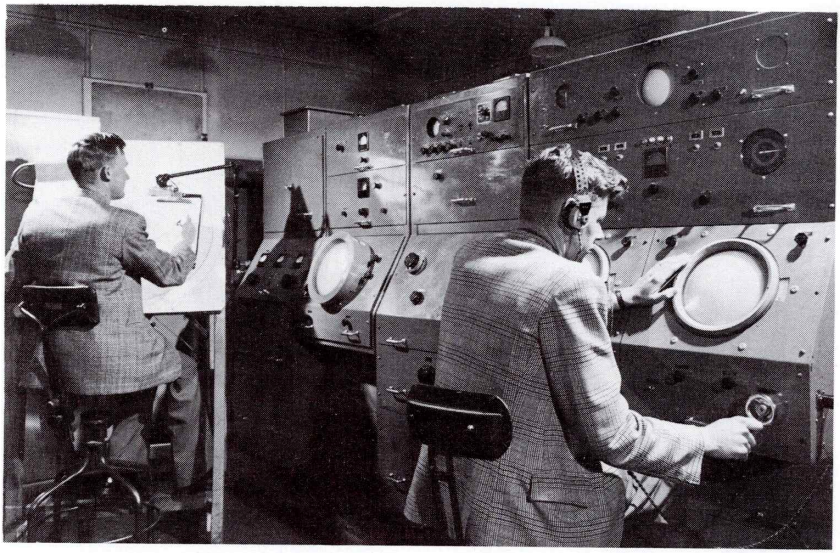
Ten authorisations enabled the Service to carry out its functions (see Appendix IV). The director was responsible for the administration of his own Service and the exercise of the powers given him by the Act, although under the general direction of the Secretary for Civil Aviation.

Dr M. A. F. Barnett

Dr. R. G. Simmers



Edith Farkas operating the Dobson spectrophotometer to measure the total ozone in the atmosphere above Wellington. About 1960.



(National Publicity Studio)

J. S. Falconer and W. Sinclair at the console of the ME7 wind finding radar at Invercargill, 1954.

(Ministry of Transport)

Communications room, General Forecasting Office, Kelburn 1957. The bank of teleprinters linked branch offices throughout New Zealand.

The situation of a semi-autonomous organisation operating within the loose overall control of a larger administrative body was maintained. The Civil Aviation Department assisted in providing accommodation while handling a substantial part of meteorological communications. The costs of this work were accepted as balancing the meteorological services to the aircraft industry. There was no extra levy from airways dues to pay for the weather reports and forecasts provided to the airlines.

Some reduction in autonomy occurred two years later when the previously separate meteorological stores and accounts section were absorbed by the Department. However this change was minor compared with the 1968 upheaval when aviation and road transport were combined into one large organisation. The Meteorological Service being attached to Civil Aviation was therefore included in the new Ministry of Transport where it is still situated. In 1972 the Marine Department was added to the Ministry.

The Ministry of Transport Act 1968 gave the director of the Meteorological Service the same responsibilities as under the Civil Aviation Act. However there was much less administrative freedom than formerly and as R. J. Polaschek, the new Secretary for Transport, remarked, 'The days of semi-autonomy of the Meteorological Service are over.' It became a very small part of a large, diverse, organisation some of whose components had little appreciation of the activities or role of a meteorological service.

Changes in directors

M. A. F. Barnett took over the Service in 1939 on the unexpected death of Kidson, and was director for twenty-three years. He was straight away confronted with directing the recruitment, and planning the deployment of, a large temporary staff and establishing a harmonious working relationship with the RNZAF and later with the American forces.

For the whole of his tenure R. G. Simmers was his deputy. Immediately on his return from post-graduate study at MIT Simmers was plunged into general administration and staff matters. Circumstances kept him to an administrative role for the rest of his career. With his extrovert and gregarious nature he was an effective complement to the more reserved Barnett.

After the war Barnett was prominent in the resuscitation of the International Meteorological Organisation (IMO) which had effectively been in recess for the war years. A conference of directors of Meteorological Services was held in London in 1946 to re-establish international meteorology and to form a convention for a body under United Nations auspices to replace the IMO. This convention was prepared in October 1947.

Barnett was on the committee responsible for its preparation, and New

Zealand was among the original 30 states which ratified the World Meteorological Organisation (WMO) convention in March 1950. One year later the last conference of directors met in Paris and transferred the functions, activities, assests and obligations, of the IMO to the new WMO which has now grown to 153 member states.

Barnett took a prominent part in WMO affairs. From 1951-1962 he was New Zealand's permanent representative serving as first Vice President from 1955-59 and continuing as a member of the Executive Committee until 1962. He also served as President of South-West Pacific Regional Association of WMO from 1951-55. Barnett was away from New Zealand on international business in most years from 1950 onwards, leaving Simmers as acting director for long periods. His twenty-three years as director were difficult ones: the war-time expansion followed by the lean years of the 1950s meant that for that whole period the Service was under stress. In addition to his international work, Barnett was active on many scientific committees in New Zealand and played a prominent part in the affairs of the Royal Society of New Zealand, serving as President in 1964. His contributions here, as in international meteorology, earned the highest respect. In all these things his judgement, tact, and quiet guidance were of immense value.

On Barnett's retirement in 1962, Simmers became director, though he retired himself in 1965. His influence however was much greater than this short period would suggest: one of his great successes was lobbying for government approval to erect the present headquarters building on its commanding Kelburn site overlooking the city of Wellington. The first designs for a replacement of the wooden building at Kelburn were drawn up before the War, and redrawn in 1949 with a view to construction in 1950. But it was not until 1964 that Cabinet approved the calling of tenders for a multi-storey building on a site adjacent to the existing head office.

Pressure on accommodation for the war-time staff had been relieved by temporary army huts behind the main building. These were to last for twenty-five years and gave the site a shanty-town appearance which did nothing to enhance the Observatory Reserve adjacent to the Wellington Botanical Gardens. With the site preparations for the new buildings in 1965, some of the old huts were demolished and replaced temporarily by a large prefabricated building. Simmers unofficially acted as an extra clerk of works, keeping a close watch on the preliminary stages of the construction work. He retired before the completion of the building, being succeeded in 1965 by Gabites. The building was not officially opened until 2 April 1968 — just over a week before the storm which wrecked the ferry steamer *Wahine* at the entrance to Wellington Harbour.

The new meteorological office enabled the general forecasting office and all head office sections to be brought under the one roof for the first time. The vast improvement in working conditions had a noticeable effect on the improvement of staff morale. Prior to the changeover, the general forecasting office was renamed the National Weather Forecast Centre (NWFC) to emphasize its national role and to foreshadow the centralisation of the main weather forecasting services for the whole country in Kelburn.

During Gabites' time as director many important changes in the Meteorological Service were started. The technological advances which resulted in the applications of computers to meteorology, the introduction of meteorological satellites, and improvements in communications, revolutionised operations. Much of the repetitive drudgery of routine tasks was eliminated and the range of applications of meteorology, increased. In turn this required better and more advanced observer training and a wider range of scientific skills.

Gabites retired in 1973 and was succeeded by Dr J. F. de Lisle who had been one of the temporary war-time forecasters in both New Zealand and the Pacific. In 1946 de Lisle left the Service and joined the New Zealand Defence Corps as a meteorologist in 1950. After post-graduate training in the United Kingdom he returned to New Zealand and was attached to the Meteorological Service which he joined in 1956. De Lisle, who was assistant director (research) when appointed as director, retired in 1977.

Because of the rapid increase in staff during the war period, many meteorologists reached retiring age at about the same time and 1977 saw the retirement of the director, two assistant directors, the officer in charge of the NWFC and the senior climatologist. The loss of so many senior staff at the same time posed a difficult problem for the new director, J. S. Hickman.

The computerised Service

Hickman started his career as an operational forecaster and had wide experience in different branches of the Service, having been at different times in charge of training, and assistant director (research). With the large number of retirements in 1977 a new-look Service emerged. Many plans which were started during Gabites' time came to fruition, which caused fundamental changes to both the organisation and activities of the Service. The installation of the Meteorological Service computer in 1978, the new satellite receiving terminal in 1980, and the higher standard of technical officer training, all contributed to a rise in staff morale. The doldrums of the 1950s were behind and recruiting prospects were improved. The Meteorological Service had been seen by the Public Service administrators as being on a

lower level than the DSIR, and salary scales reflected this. Efforts to change this began with Simmers fighting for parity of meteorologists with other scientists in the Public Service. It was continued by his successors and finally achieved in 1972. Battles were also fought for a modest increase in the numbers of meteorologists and technical officers; a streamlining of activities within the Service to allow a greater proportion of the effort to go into research and development; an increase in the level of technician training and support; and access for the Service to the latest technical advances especially in computers.

Each advance was inevitably preceeded by administrative reviews of the Service. Assessments were made by a succession of working parties from the State Services Commission, the Ministry of Transport, and the National Research Advisory Council (NRAC). This latter body was set up in 1963 to advise government on the promotion and development of scientific research in New Zealand and the planning and co-ordination of research and scientific services. In its 1966 report it drew attention to the economic benefits that would accrue from improved meteorological services but pointed out that their realisation depended on more research and less preoccupation with routine services. The recommendations for more staff and a doubling of research effort in five years were a welcome endorsement of the Service's own goals. However, their realisation was quite another matter.

The question of the appropriate administrative body to control the Meteorological Service was again raised in 1970, when Cabinet requested the NRAC to make a recommendation on the most suitable location within government departments. It appeared somewhat incongruous that the Meteorological Service was part of a ministry whose main function was to 'advise the Minister on the development of an efficient transport policy for New Zealand'.

In its 1970 report the National Research Advisory Council recommended that there be no immediate change in administration, and this remains the situation today. The report also recommended an upgrading of computer facilities and of technical support to professional staff; the classification of the professional staff within the science occupational class of the State Service; and the establishment of a chair of meteorology at Victoria University of Wellington. The chair of meteorology failed to find a financial sponsor either within government departments or the private sector; however the other main recommendations were gradually implemented. Their effect on the scientific activities of the Meteorological Service and on the increased scope of the services to the community will be outlined in the remaining chapters.

Staff training

Technical officer training

Technological advantages in meteorology have brought the necessity for a continuing review of the training given to both meteorologists and observers. Originally the job of the technical assistants was to look after the instruments, make the observations and present them to the meteorologist for analysis and interpretation. The title of observer was a fair description of the duties. However the introduction of wind-finding radar and the radiosonde increased the technical content of the job. Since their introduction there has been an acceleration in technological change. This widened job content by meteorological observers meant a different kind and level of training was necessary.

The change in training procedures of meteorological observers and the increased content of their duties was recognised in 1972 by a change in status. They were brought into line with technical assistants in other government scientific organisations and became meteorological technical officers. The reclassification of observers to technicians was a gradual process not being completed until 1978.

After the loss of many of the war-time observers there was an urgent need for replacements. The first group of 26 civilian observers were trained in a meteorological school held at the RNZAF Base Woodbourne in 1946 under M. S. Butterton and a small staff. Butterton had joined the Service in 1937 and in the post-war period became superintendent of reporting and training, responsible for both the reporting networks and training of observers. With the establishment of a separate training section in 1972 he became responsible for the reporting networks only. His frequent visits to the stations both within and outside New Zealand gave him an unrivaled knowledge of the observing staff and their families in whom he took great personal interest.

After the demobilisation of the WAAFs at the end of the war only two stayed on and the technical side of the Service was almost totally a male preserve for many years. Because of the limitations prior to the war on the employment of women on night shifts in the Public Service, the Meteorological Service had no women meteorologists or observers. With the easing of restrictions and the authority to provide taxis for night workers, the first woman observer was appointed in 1964. Numbers have since increased and women have been included in the Campbell Island expedition.

Formalisation of the instruction courses and the establishment of a two-level examination system for junior and senior staff came in 1947. With the withdrawal of New Zealand observers from the Pacific Islands, training was

extended to Pacific Island observers to stabilise and maintain their meteorological standards.

Within New Zealand, courses were held as required, mainly in Wellington until a Civil Aviation College for the training of meteorological service observers, air traffic controllers and communications officers, was established at Christchurch International Airport in 1962. This was a full-time organisation where all meteorological observers received their initial training. Much of the training for the senior qualification was done by correspondence after a period of being on the job.

By the mid 1960s it was quite obvious that a change was coming in the type of duties that an observer would be required to do. Special two week refresher courses on the physical properties of the atmosphere and climatology were begun. There was an emphasis on aviation briefing duties, and on dealing with general enquiries from the public. This was followed in 1967 by a one month course for senior observers which included mathematics and dynamical meteorology. Many who had done no study since passing their senior examinations years before, found the course demanding.

The series of refresher courses continued until 1972 when a special training section was formed to be responsible for all technical officer and meteorologist training in the Service. Since then there has been a broadening of the course content to better suit technical officers acting as aviation briefing officers, and for forecaster's assistants to give a more effective liaison with the public.

With most Pacific Island nations becoming responsible for their own meteorological services, the training section has provided courses ranging from introductory to management, for those who may one day be in charge of a Service. Technical officers from Fiji, Western Samoa, Kiribati, Tuvalu, Vanuatu, Papua-New Guinea and, Tonga have all come to New Zealand for meterological training.

Training of meteorologists

Because New Zealand universities do not offer complete courses in meteorology, recruits are given a comprehensive in-house course of eight months. Before the 1972 restructuring of training, the formal course was 3-4 months followed by on-the-job training in weather forecasting duties before a transfer to one of the sections of the Service.

A university degree, usually in mathematics or physics, is still a pre-requisite for entry as a meteorologist and presently honours or higher qualifications are required. The course given is intended to provide an introduction to meteorological theory and to the practical skills needed for work in any branch

of the Service. It is supplemented by attendance at two out of the three courses offered at Victoria University: Dynamical Meteorology, Physics of the Oceans and Atmosphere, and Physical Meteorology. Trainees are given a wide knowledge of the work of the Service and are able to express an informed preference for posting on completion of the course.

After some work experience those who are able to benefit are encouraged to apply for study awards for post-graduate study. At present this usually means attending an overseas university.

Paying for the Meteorological Service

It is only relatively recently that governments, both in New Zealand and elsewhere have looked critically at the costs of supporting their scientific departments with public funds. With the increasing use of the advice from these departments for private gain there is widespread opinion that the 'user pays' principle should be more consistently applied.

For nearly the whole of its existence the Meteorological Service has charged for its services only on rare occasions. Being funded by the taxpayer the weather forecasts and meteorological advice were the public return for the funding. In a few cases charges were made to commercial organisations where information had to be especially provided. The Service was not set up as a commercial organisation and there was no comprehensive policy on charging.

This began to be questioned in the early 1970s when non-trading departments were ordered by government to investigate how a greater proportion of their running costs could be offset by charging. The Service carried out a number of these exercises but there were no significant changes in procedures or in the financial returns from its clients. The revenue from charging rose to about six per cent of the expenditure.

It was not until 1985 that the matter was dealt with seriously and a system formulated which laid down the kind of information that should be charged for, together with a scale of charges. The general concept was that where the basic meteorological activities of data collection, weather forecasting, climatology and research were not carried out for the overall 'public good' they should not be state funded. 'Public good' was defined and charges were based on identified costs plus a proportion of the general overheads of running the Service. It is the present aim to recover 35-40 per cent of gross costs by the early 1990s.

The idea of a meteorological service becoming a commercially active organisation seeking to develop new skills, and provide a wide range of consultancy services, is quite new. In New Zealand, unlike some western

countries, there is little competition in the provision of meteorological advice. In spite of its almost monopoly position, it appears that in the new economic climate the Service will have to justify itself to retain adequate state funding. Part of that jusification will be measured by the rules of the market place on the success in selling services. This is an entirely new situation and its effects on meteorological science remain to be seen.

6

Atmospheric observations

Over the last forty years technology has provided the meteorologist with an increasing number of sophisticated sensing devices, giving atmospheric data previously unobtainable. The sheer volume of atmospheric information now gathered each day would be impossible to collect and use, without the accompanying systems of automatic recording, high speed dissemination, and computer processing. This is especially so, in the observations made for the analysis and forecasting of global weather systems. Whereas Southern Hemisphere meteorologists were once resigned to dealing with large data-sparse ocean areas, the position now is more hopeful.

The Meteorological Service has gradually obtained the means to take advantage of much of the information provided by the new systems. Acquiring the data on which it depends for its operations, has always been by far the most expensive part of maintaining the Service. If the instrumental and administrative costs, plus the charges for communications, are apportioned between the main activities of the Service, then the acquisition of data takes just under half the annual expenditure.

From its earliest days the Service has obtained the basic observations within New Zealand from whatever source it could. It had relatively few paid observers, and of those making the observations, the majority were employees of some other organisation such as the Post Office, Marine Department, Local Bodies — or private individuals, who through interest made daily observations. Our knowledge of the rainfall distribution would not be as detailed as it is without the hundreds of voluntary observers, and the use of modern devices has not made simple conventional observations obsolete. Dr Knight or Sir James Hector would find much in the numerous climatological enclosures around the country, with which they had been familiar.

There are three broad classes of weather observations with which the Service is concerned:

- Those made at both the surface and in the upper air at various levels, primarily intended for charting the movements of weather systems — the so called synoptic observations made at internationally agreed times for weather analysis and forecasting. To these must be added the information

from meteorological satellites, drifting buoys and aircraft used for the same purpose.

- Those used for the study of climate.
- Special observations made for research purposes which are dealt with in a later Chapter.

The synoptic station network

With the increase in RNZAF bases during the war, the number of stations directly controlled by the Service in New Zealand and the Pacific grew to 32. Regular observations received from these stations, and from others in the networks, together with reports from aircraft flying in the area, gave a much better data coverage of the South-West Pacific than had ever occurred before.

There was a drastic scaling down in 1946 with only 20 branch offices left in New Zealand and the Pacific. By 1950 this had grown to twenty-four locations at which meteorological staff were stationed. Besides reports from these places, regular reports of surface weather made by other agencies were also received from 95 stations within New Zealand and 14 in the Pacific. Today the Service maintains 21 stations in New Zealand and its off-shore islands, and receives surface reports from some 120 other places within the country.

The upper air network of radiosonde and radar-wind stations also suffered a reduction and rearrangement in 1946, and by 1950 upper air temperature soundings were made at five stations and radar wind flights at four. The changes that have taken place since then, in both the instrumentation of upper air stations and their location, are described below.

One welcome addition to the weather data received for weather map analysis from 1946 onwards, was from merchant shipping whose weather reporting activities had ceased during the War for security reasons. A marine officer was appointed in Wellington in 1947 and another in Auckland in 1950, to encourage ships calling at New Zealand ports to broadcast their weather observations regularly. Those vessels visiting New Zealand regularly were invited to join the Service's list of specially selected ships and were provided with meteorological instruments if necessary. The marine officer visited them when in port, to collect the documented record of the reports broadcast, and inspect the instruments. In the first year, sixteen ships were recruited and over 5000 reports received from vessels in the New Zealand area. The fostering of weather reporting from shipping has continued and today there are some fifty ships on the Meteorological Service register of selected ships.

A change to metric units for all meteorological measurements began in

1970, following a government decision to metricate all physical units in New Zealand, and from July 1971 all public weather forecasts gave rainfall and temperature in metric units only. This involved the Service in replacing Fahrenheit thermometers and rainfall measuring cylinders not only at its own stations, but at all climatological stations in New Zealand and in the Pacific. The final phase in metrication in the Service was in July 1973 with the reporting of visibility.

Automatic weather stations

The small number of stations reporting during the night had long caused difficulties in producing the first weather forecasts of the day. The position became acute with the automation of lighthouses, — the consequent reduction in the number of keepers drastically curtailed one of the main sources of night-time reporting. The idea of supplementing the reporting network with automatic weather stations was therefore appealing, and in 1962 a market survey was carried out to see whether any commercial equipment was suitable for the New Zealand situation.

Years previously the Service had experience with an early type of automatic station. After the war it made offers for some of the American meteorologial equipment abandoned in the Pacific, and one offer, said to be for $US10, was accepted for a Friez automatic weather station on the French Chesterfield Reef between New Caledonia and Australia. The Public Works Department vessel *New Golden Hind*, with meteorological observer S. E. Besley on board, brought it to Wellington where it successfully operated on test but was not used in the field.

The 1962 market survey was unsuccessful and the Service at the time lacked the staff and skills to do anything about local production. Its electrical engineering requirements were looked after by Civil Aviation, which was itself fully extended without doing developmental work for the Meteorological Service.

In 1968 an electrical engineer, R. A. Pannett, was appointed to the Service and given the task of designing an automatic data logger, to be the first stage in the production of an automatic weather station. By 1970 the instrument section had completed its design and held discussions with the Post Office on the use of Telex for the transmission of weather reports from unattended stations.

A prototype station was successfully tested, being designed to record temperature, pressure, humidity, wind speed and direction, and rainfall, and able to be interrogated from a central location (Kelburn). Tenders for eleven stations were called early in 1975, and the pilot network completed in 1977.

The current automatic weather station network consists of twenty-four stations which are interrogated from Kelburn every three hours with occasional non-routine calls when needed. The Telex System is interfaced with the Meteorological Service computer so that station interrogation and the receipt of the reports is also automatic. One station, Puysegur Point in remote Southland, reports back via a TIROS-N polar orbiting meteorologial satellite.

Initially the automatic weather station programme was directed at improving the night-time coverage of weather reports but it has been extended to placing weather stations in remote areas. The system has a reporting failure of about 10 per cent at the fixed reporting times and 98 per cent of the failures are due to faults in the Telex network. An improvement in the communications medium is necessary for a better weather station performance.

After commissioning of the automatic weather station network, more lighthouses became fully automated, and in 1985 only eight manned lights were left around New Zealand. The latest to lose all its keepers was Farewell Spit, which sent its last manual report in June 1984. Weather observations were first made there on 1 January 1874, as part of Capt. Edwin's storm warning network.

Climatological observations

The system of climatological observations started in 1861 by Charles Knight, has continued to the present day and produces the basic data from which the statistics on New Zealand's climate are derived. Monthly returns of the daily observations are sent to Wellington from stations spread throughout New Zealand and the Pacific. By the use of electronic data processing, climatic information can also be obtained by summarising from the more frequent observations (some at hourly intervals) made for synoptic purposes.

In 1946 there were about 90 climatological stations in New Zealand. It took twenty years to grow to 200 stations and a further ten years to reach 300. The observers at most of these stations are employees of other organisations and in some cases the Meteorological Service makes a payment for their work. The Forest Service, catchment boards, local bodies, Ministry of Agriculture and Fisheries, Post Office, DSIR, and Ministry of Energy, all maintain climatological stations. Without their assistance there would be very few stations in New Zealand.

Even though the once-daily climatological observations are, in the main, made with simple instruments, the results would be inaccurate without a meticulous regard for the care of the instruments and a use of standardised methods of observation. This can only be guaranteed by careful scrutiny of

the monthly returns at Kelburn, and a regular programme of inspection of the stations.

While weather observations have been made in a systematic fashion in New Zealand since 1861, there is no homogeneous station record anywhere near 100 years in length. Changes in observation site, either from one location to another, or alterations in the environment through the growth of trees or erection of buildings have altered microclimates.

Today the Service employs five inspectors, who aim to visit each climatological and synoptic reporting station every two years, and each of approximately 1000 rainfall stations every five years. Inspection has been decentralised, and inspectors are based at Auckland, Wellington, Christchurch, and Invercargill, to ensure a greater frequency of visits than was formerly possible.

New sensing and recording devices have given the possibility of obtaining climatic data from other than the mostly populated locations of the Service's 300-odd stations which report once a day: the environmental data logger has been used in isolated areas from which manual observations are unobtainable, and the full exploitation of satellite data by more complete computer processing than is at present carried out in Wellington, will enable additional microclimate information to be obtained.

Rainfall observations

From the colonial days in New Zealand settlers needed as detailed a knowledge of rainfall as possible, for use in the practical civil engineering problems the country posed. Large rainfall differences in relatively short distances, required a dense network of stations which the Service did not have the resources to provide.

We have already noted the lack of co-ordination among the bodies making rainfall observations, and Kidson's plea for some control over the inefficient use of public resources through duplication and inadequate supervision of the observations. The Public Works Department (PWD) set up its own network of stations, and in 1913 Bates noted in his annual report that he was about to issue another five hundred gauges to the PWD. Again in 1932, Kidson said that because the Meteorological Service was unable to meet the community needs, the PWD had itself bought five hundred gauges.

There were thus two independent major rainfall networks and rationalisation was never achieved. The Meteorological Service and the PWD had different objectives: the Service wanted the whole country covered with rain gauges as closely as practicable, to enable it to give rainfall distribution and

intensity information to a wide variety of users — it aimed at continuity of observation; the PWD operated more as a rainfall shock-troop, moving into a district where it needed immediate data for civil engineering construction purposes, flood control works, or erosion control.

The Service depends mainly on its voluntary observers for basic rainfall observations, and many individuals and families have faithfully recorded daily rainfall for extraordinarily long periods. In 1979 N. Watson of Waiheke Island retired after sixty-six years as a rainfall observer, a record equalled by G. Beattie of Rangiora. Some farming families have through several generations maintained continuous rainfall records for even longer periods.

From the 1860s, in the days of the Provincial Governments, there have been River and Drainage Boards and River Trusts in New Zealand. Rapid clearing of forests brought flooding and consequent soil erosion, and there was need for river control, so that eventually the requirement for dealing with erosion was seen to be as urgent as river control itself. A Soil Conservation and Rivers Control Act of 1941 gave the legislative framework to tackle these problems, and between 1943 and 1955 thirteen boards were formed covering 90 per cent of the country.

The 1967 Water and Soil Conservation Act combined the control of all aspects of water use, flood control, and erosion. It set up a National Water and Soil Authority whose executive bodies were the Soil Conservation and Rivers Control Council (SCRCC) and the Water Resources Council, both serviced by the Water and Soil Division of the Ministry of Works and Development. One of the urgent needs of the SCRCC was data on the distribution of rainfall amounts and intensities and of river run-off. The later was the concern of the Ministry of Works, but the Meteorological Service held the national archives of rainfall and began a close collaboration with the SCRCC.

The Service planned to increase its rainfall network to 1100 stations and to attempt to supplement its own records with those from unofficial records held by local bodies and private individuals. There were also plans to install 100 self-recording gauges for the study of rainfall intensity. By 1964 the number of simple manual raingauges on the Meteorological Service register had reached the goal of 1100 and has stabilised since then at between 1100 and 1200. Today records are also received from over 110 private gauges and the Service operates more than 110 automatic gauges within New Zealand as well as receiving rainfall data from the Pacific Islands.

N. G. Robertson, who took charge of the Climatological Section in 1946 after Seelye, made a study from the automatic records of the frequency of high intensity rainfalls in New Zealand. His 1963 publication filled an important gap in the basic information needed by engineers. He drew

attention to the tendency to take for granted the amount of patient monotonous work in producing the rainfall statistics on which so much civil engineering, land management, and agriculture depends. While patient scrutiny of the records is still needed, some automation of the chart scaling from automatic raingauges has now been introduced.

Independently of the Meteorological Service, both the catchment boards and the Ministry of Works and Development (MWD) developed rainfall networks for their own purposes. In 1985 there are about 100 gauges operated by the catchment boards and about 1000 by the MWD. While there is a free interchange of data from the separate organisations each goes its own way.

Measurement of upper winds

Although at most of the Meteorological Service stations upper winds were originally monitored by pilot balloon, four of the New Zealand designed ME 7 radar sets were eventually produced and installed in Nandi, Auckland, Christchurch, and Invercargill. They became the mainstay of the New Zealand wind-finding network and gave long service. The first, which had been sent to Whenuapai for trials in 1944, was not pensioned off until 1964 and was donated to the Auckland Museum of Transport and Technology (MOTAT). The ME 7 radars were supplemented by four British military-type GL 3 radars, the first of which arrived in 1950.

A maintenance organisation to service the radars was originally set up by the DSIR, but when the Civil Aviation Branch appointed a principal radio engineer, the technicians transferred to Civil Aviation. Keeping the old radar sets serviceable became an increasingly difficult job in the late 1950s and approval for a replacement system was received in 1958. An order for eight 'Cossor 353' sets was placed in Britain the following year. The first set arrived in Wellington in 1963 and the installation of the eight was spread over several years.

These Cossor sets had the added facility of acting as weather surveillance radars, from which the distribution of rainfall around the station could be found, and rainfall area, intensity, and rate of change deduced. As these quantities are of interest both to catchment authorities and to the Electricity Department for scheduling hydro-electric power generation, an investigation was carried out by the Service in 1970 into the feasibility of using weather radar to scan the central North Island. A mobile airfield surveillance radar was moved to a hilltop near Taupo for trials. Financial restrictions and lack of outside support finally ended the implementation of the project.

The Cossor sets gave good service, but by 1981 a start was made on

modernising the network. It was decided to split the wind-finding and weather surveillance functions. The wind-finding stations are being equipped with either X-band (3.3 cm) or C-band (5.5 cm) radar. The latter are installed at 'observatory stations' where soundings are regularly made to a height of 30 km. American C-band radar sets have been installed at Kaitaia, Paraparaumu, and Invercargill, which are to be the main New Zealand wind finding stations. The set at Invercargill was badly damaged in the January 1984 floods. A further C-band set has been installed at Rarotonga. X-band sets are located at Christchurch and New Plymouth, while an additional set has been procured as a mobile research set.

Although approval has been received for the separate weather surveillance radar network, installation has yet to start and currently the old Cossor 353 sets are still used for this purpose at Whenuapai and Ohakea.

Radiosonde observations

After the experimental radiosonde flights in Wellington in 1934, the only measurements of upper temperatures made in New Zealand until 1942 were from the aircraft meteorological flights at a number of RNZAF bases. The American Forces brought radiosonde equipment to Auckland, and made soundings in 1942 using a Diamond Hinman receiver of Friez manufacture. The set was taken over by the Meteorological Service and eventually six radiosonde stations using American transmitters and, receivers were established both in New Zealand and the Pacific. By 1950 this was reduced to five stations.

The Service began to replace the American radiosonde transmitters used in New Zealand by the British Kew instruments in 1950. The latter have a much faster rate of ascent and in the strong westerly winds over New Zealand a slow balloon ascent rate gives a long slant range and an early signal loss. It was decided to keep the American transmitters for the tropics. However uncertainties in the supply of British transmitters caused a reversion to American equipment. Until March 1975 the Service offered a small reward for the returned radiosonde transmitters which, if not too badly damaged on landing, were reconditioned.

The war-time ground receiving sets, which gave remarkable service, were rebuilt in 1961, with much of the new equipment being constructed by the Civil Aviation Administration. Other changes to the system since then have been the replacement of valve circuits by transistors and the alteration in transmission frequency from 72.2 MHz to 403 MHz to conform to new international frequency allocations.

Meteorological communications

Weather forecasting would be impossible without the rapid collection and transmission of observations from as wide an area as possible. For New Zealand this area extends from the Indian Ocean in the west, to Pitcairn Island in the east, and from the equator to the South Pole. A highly organised and complex telecommunications system is necessary to collect the individual reports, and channel them into regional centres for onwards transmission to other meteorological services. The times of observation, the codes in which the observations are reported, and the means of exchange of the reports from a region with other meteorological services, are laid down by the WMO after international agreement.

The present complex communications network in the South-West Pacific developed from simple beginnings. Before the war, the Post and Telegraph Department provided the communications service in New Zealand for the Service. The major changes during the war were the introduction of teletypewriters linking the meteorological service's branch offices, and the further development of the Aeronautical Fixed Telecommunications Network (AFTN). The teleprinters were controlled by the Post Office and operated mainly by members of the Womens Auxilliary Air Force (WAAF).

The aeradio system had been introduced by the Post Office in 1936 to provide point to point, and ground to air, communications for aircraft. By 1939 it covered sixteen airports in New Zealand and a special station was built at Musick Point in Auckland for international flights. The aeradio network was integrated with the RNZAF communications system in 1943 and taken over by the Civil Aviation Division in 1947. It had early combined the transmission of flight safety information and weather data in the one network, the AFTN. A new expanded network was introduced in November 1946, which saved a duplication of radio messages and enabled the use of multiple address Post Office telegrams for weather reports and forecasts to be discontinued.

After the war similar communication arrangements continued. Throughout the Pacific, and within New Zealand beyond the limits of the teleprinter network, the meteorological communications facilities were provided either by the telecommunications section of Civil Aviation or by the appropriate Post and Telegraph Department.

In October 1954 the staffing of the communications centre at the general forecast office, Kelburn, was taken over from the Post Office by Civil Aviation. There was initially a staff of eight and the centre had thirteen teleprinters

linking most of the meteorological branch offices and the General Post Office, Civil Aviation Communications Centre and the Wellington Radio station ZLW. Whereas initially the messages made up of the collected reports — known as a 'collective' — had been sent out manually by morse code, they were later punched on a perforated tape and the process became semi-automatic. Eventually all collective messages were automatically received and transmitted.

The Australian collectives, and Pacific collectives from Nandi, were received in New Zealand by radioteletype on the AFTN circuits linking Sydney, Auckland, Honolulu and Nandi. These contained surface and upper air reports from land stations and ships, aircraft reports, and coded weather maps. All information was in five-figure code and by 1950 Wellington and Nandi were both receiving 9000 five-figure groups daily.

Nandi continued to act as the broadcasting centre for the Pacific Island reports until 1956, when it was replaced by Wellington. The collectives were assembled from the various regional sources and broadcast by the Post Office radio station at Himatangi.

The need for rapid distribution of copies of weather charts from Wellington, for the guidance of branch offices, brought about the introduction of facsimile equipment. By early 1961 lines were open between Kelburn, Wellington Airport, and Ohakea, and also between Mechanics Bay, Auckland, and Whenuapai. This enabled the main offices to send material that would have been uneconomic for the branch offices to produce themselves.

The World Weather Watch of the WMO, when launched in 1963, was described '. . a fully co-ordinated world wide scheme, the primary purpose of which is to make available, within the agreed system, meteorological and other environmental information for both applications and research'. It nominated three World Meteorological Centres, Washington, Moscow, and Melbourne, and a number of regional centres of which Wellington is one. The Global Telecommunications System (GTS) was an important element of the World Weather Watch, and Wellington was also designated as a Regional Telecommunication Hub for the collection and transmission of weather observations from the South-West Pacific.

There were certain requirements for each type of meteorological centre, and in order to fulfil its obligations New Zealand was required to modernise its facsimile system. In September 1982 a meteorological radio-facsimile broadcast system commenced routine operation. The branch offices, including the Chatham Islands and Rarotonga, and ships at sea, could then receive the broadcasts of weather maps. In 1982 the National Weather Forecasting Centre (NWFC) at Kelburn was preparing 51 charts per day for radio facsimile broadcasting. These were sent by landline from Wellington to the transmit-

ters at Wiroa Island at Auckland International Airport. The broadcasts had a range of 10,000 km.

By 1981, the AFTN system was modernised and, as well as fulfilling its aviation purposes, had become an essential part of the WMO Global Telecommunication System. Today Wellington receives weather information from the Pacific national meteorological centres and from the World Meteorological Centre at Melbourne. It passes to Melbourne the Pacific and New Zealand observations for onwards transmission to the rest of the world.

Meteorological satellites

The meteorological satellite is the most impressive of the new sensing probes which gather atmospheric information. In its most recent form, not only does it give an overview of global cloud systems, but also quantitative measurements of some atmospheric variables. The Southern Hemisphere meteorologist is now provided with information from vast empty oceans.

For some time after the first launching of the meteorological satellites in 1960, there was no read-out station in New Zealand to intercept the transmissions. After the early pictures had been analysed in Washington, cloud type and extent were coded in a form which allowed a reconstruction of the original, and these were made available outside the United States. Cloud pictures from the early TIROS satellites, covering middle and high latitudes in the New Zealand region, were received here in coded form from 1960.

In 1964 the Service made a grant of £5000 to the Department of Electrical Engineering, University of Canterbury, for the development of a prototype ground station receiving system to intercept satellite transmissions. It was hoped that receiving sets could then be manufactured in New Zealand.

Meanwhile the United States Navy 'Deep Freeze' headquarters in Christchurch had installed a satellite read-out station, to give weather information for the American flights to McMurdo Sound in the Antarctic, and obviate the need for picket ships in sub-Antarctic waters. The 'Deep Freeze' authorities made the cloud pictures available to the Meteorological Service.

The American ESSA-2 satellite launched in March 1966, on a near-polar sun-synchronous orbit, was fitted with the Automatic Picture Transmission facility (APT). The Christchurch branch office of the Service used the Deep Freeze equipment to obtain the cloud pictures on a regular basis for transmission by facsimile to other meteorological offices around the country. The Canterbury University prototype was tested on the same transmissions and in the following year the equipment was moved to Wellington for trials which proved successful.

The pictures received in New Zealand had all been day-time images taken

in the visible wavelengths of the radiation spectrum. Later meteorological satellites had the APT feature in the infra-red wavelengths enabling night time transmissions to be received. As it had been found impracticable to have the Canterbury set manufactured in New Zealand, commercial equipment was brought from overseas able to detect in both the visible and infra-red. One set was installed in Wellington in 1970, and another at Nandi where the ability to locate the position of tropical cyclones was to prove of great value.

The hundreds of satellite cloud pictures received in Kelburn provided many problems in interpretation, and much information of a descriptive nature was gained on the manner in which the broken topography of New Zealand affected the formation and distribution of cloud. Although the cloud images could sometimes give information on the upper winds and the temperatures of the cloud tops could be deduced, there was little quantitative data in a form readily suitable for use in numerical weather prediction. The prospects changed however, with the success of the infra-red vertical sounding experiments carried on the NIMBUS III and IV satellites launched in 1969 and 1970. These made it possible to obtain the vertical temperature structure with reasonable accuracy, and infer a crude water vapour profile. Later improvements in satellite instrumentation refined these measurements.

In order to take advantage of the new technology, planning for a new APT terminal for Kelburn started in 1976. This was designed to receive data from the American and Japanese geostationary satellites, located over the equator at longitudes 136 °W and 140 °E respectively, as well as from the polar orbiting satellites. An integral part of the station was to be the Meteorological Service's computer which would be needed to process the large amount of incoming information.

French satellite receiving equipment was installed during 1970-80, requiring substantial modifications to the Kelburn building to accommodate two two-metre dishes for the geostationary satellite and a three-metre dish for the polar orbiting satellite. The terminal, which was officially opened in September 1980, produces:

- Cloud pictures in the visible and infra-red wavelengths at the high resolution of 1.1 km.
  These are computer processed to fit a standard map projection covering the immediate vicinity of New Zealand, and the outlines of the land masses are added: Pictures are received four times a day.
- A mosaic, from a number of satellite passes, of the cloud cover at low resolution, over an area from the equator to latitude 60 °S and from longitude 199 °E and 140 °W.
- Vertical profiles of air temperature and of water vapour.

- Sea surface and cloud top temperatures.
- Data from the automatic weather station at Puysegur Point.

The current WMO World Weather Watch plan envisages two complementary satellite systems continuing for the period 1984-87. The systems are composed of:

(a) Polar orbiting satellites at heights of 800-1000 km in a near polar orbit comprising American and Russian systems, each with two operating satellites in orbit at any one time.

(b) A geostationary satellite system in a geosynchronous orbit at 36000 km over the equator, comprising six satellites located at longitudes 140 ° E (Japan), 74 ° E (India), 70 ° E (USSR), 0 (European Space Agency), 75 ° W (USA), and 135 ° W (USA).

Any country with the necessary receiving equipment is at present able to take advantage of the APT facilities of the appropriate satellites of the World Weather Watch plan. The availability depends on the operational state of the particular satellite, with failures leaving a gap until there is a replacement.

With its present satellite station and computing system, New Zealand is well placed to take advantage of much of the satellite data relevant to its area of interest. However transmissions from the satellites contain much more information than is currently derived: land surface temperatures, soil water estimates, snow cover, and estimates of water and water vapour, are all available, but need greater computer power than the Service possesses. These quantities have a direct application to the use of New Zealand's natural resources. More refined methods of pictorial cloud presentation are not used, also because of present limited computer processing facilities.

7

The Meteorological Service outside New Zealand

After the withdrawal of most of the RNZAF units from the Pacific in 1945-46, the Service acquired added — rather than reduced — responsibilities, because of the need of the new trans-ocean airlines for weather reports and forecasts. The overseas commitments were to grow and then in more recent years to alter in character with the changing political scene in the Pacific. Since 1946 New Zealand Meteorological staff have served at weather stations ranging from Tarawa, in Kiribati just north of the equator, to the United States Scott-Amundsen base at the South Pole.

The Service has played a major role in the consolidation of a network of reporting stations in the South-West Pacific, in the emergence of the Fiji Meteorological Service, and in assisting other Pacific nations towards managing their own meteorological affairs. While meteorologists have been stationed only in Fiji and in the Antarctic, elsewhere the Service has been represented by its technical officers. The isolation of many stations and consequent remoteness from head office in Wellington, gave opportunities for initiative and independence which would not have occurred back in New Zealand. Over the years the many overseas stations have provided the chance to work in interesting and exotic locations, which a totally New Zealand based organisation would never have given.

With the coming of independence to Island territories, and the replacement of most expatriate meteorological staff by local, there are not the same opportunities for overseas service that there once were. New Zealand's assistance to Pacific meteorology is changing to an advisory and training role.

New Zealand's own outlying Islands, Raoul, Campbell, and the Chathams, and the Ross Dependency in the Antarctic, still give young technical officers the chance for service abroad. These places require resourceful, adaptable, and stable people, who can live in small isolated communities for long periods. Those with such qualities often find a fascination in working on remote stations and after one tour of duty many have returned for a second or third tour.

This Chapter records briefly, the involvement of the Service with those stations outside New Zealand where its staff have served. These are:

Fiji	Kiribati (Gilbert Islands)	Campbell Island
Western Samoa	Tuvalu (Ellice Islands)	Antarctica
Cook Islands	Chatham Islands	
Tonga	Raoul Island	

Fiji

After the establishment of the South Pacific Air Transport Council (SPATC) in 1946, W. R. Dyer stayed on at Lauthala Bay as the Principal Meteorologist (Islands) to reorganise the Pacific weather reporting network and forecasting services. In spite of some outside help, the Service in New Zealand was only able to fulfill its obligations in the Pacific at the expense of activities at home — where services to aviation and to the public suffered, and research was practically non-existent.

Under the SPATC agreement New Zealand had accepted responsibility for the development and control of the meteorological services needed for the civil aviation air routes throughout the British territories east of longitude 170 ° E. Nandi became the forecasting centre, and Dyer was stationed near the seat of government at Suva.

Local weather services — including hurricane warnings for the public, storm warnings for shipping, and climatological advice — were required, and were the subject of a separate agreement with the Fiji Government. Nandi also provided forecasts for Western Samoa, the Cook Islands, and the Gilbert and Ellice Islands (Kiribati and Tuvalu); and was responsible for hurricane warnings for the New Hebrides (Vanuatu), American Samoa, and all the British territories in its region of control. Because of the vulnerability of the Islands to tropical cyclones, the warning system operated by Nandi was one of its most important and difficult functions. During the period November to April 1939-1969 a total of 130 tropical cyclones were tracked in the area east of longitude 170 ° E. In the days before meteorological satellites RNZAF aircraft were often used to locate storm centres.

In 1947 three Pan American Airways meteorologists were attached to the New Zealand Meteorological Service, two at Nandi and one at Auckland. The prospect of their withdrawal in 1948 precipitated a manpower crisis. Barnett recommended to the Air Secretary that:

1. Dyer be recalled to New Zealand where he could combine the administration of the Islands meteorology with other duties, and
2. Britain be asked to take over the Colonial Meteorological Service in Fiji early in 1949, and if unable to do so, be asked when control could be as-

sumed; and as a stopgap provide four qualified forecasters for duty at Nandi.

The Colonial Meteorological Service did not replace New Zealand in Fiji, but Britain supplied a series of weather forecasters for Nandi from the 1950s onwards. Dyer returned to Wellington in 1948, and Lauthala Bay became the centre for the climate and station inspection services — and somewhat of a meteorological backwater. The Nandi office at the International Airport gave a round the clock seven-day forecasting service.

The introduction of jet aircraft into the South Pacific brought new meteorological problems. The requirement for forecasts of upper winds and temperatures at higher levels, called for an extension and upgrading of radar wind and radiosonde stations. In 1959 the SPATC reviewed the reporting network in the light of jet aircraft needs. It had previously set up a study group to assess the economic significance to jet flying in the South-West Pacific of additional upper air stations. The result was to be the eventual establishment of upper air stations at Tarawa, Funafuti, and Rarotonga. At Nandi, the old New Zealand-designed ME7 wind-finding radar was replaced in 1966 by the new Cossor 353 radar with a weather surveillance capability. In 1970, satellite receiving equipment was installed, proving an invaluable aid during the hurricane season.

The SPATC had a policy of encouraging an increase in the numbers of locally recruited staff, including professional meteorologists, at the Island stations. It was evident that the colonial status of the British territories in the Pacific would not continue indefinitely, and the use of expatriate staff was only a stopgap measure, until there could be technical independence along with political independence. This proved to be a long-term process and depended on the training programmes both in New Zealand and Fiji.

By 1962 good progress had been made in replacing New Zealand observers in the Pacific by local staff. There were only ten New Zealanders left, and this was expected to reduce to five within five years. Lauthala Bay was the first station to be fully staffed with Fiji nationals, when in May 1965 Pita Rakoroi took over as officer-in-charge. He was one of three Fijians appointed by Dyer in 1942, who had made a career in meteorology. Of the other two, Isei Tudreu became the chief observer at Nandi, and Joseva Natau the inspector of reporting stations based at Lauthala Bay.

The last New Zealand observer left Fiji in December 1965, and from then on all technical officer functions were carried out by members of the Fiji Government Service. The only ex-patriates left were the officer-in-charge and some forecasters at Nandi. It had taken twenty years to completely replace the war-time peak of thirty expatriate observers. Many of the senior Fiji

staff went to New Zealand on training courses, and in their turn conducted courses in Fiji not only for the Fiji Service but also for observers from other island groups.

Replacing the professional meteorologists presented a much more difficult problem. Fiji, in common with technically developing countries around the world, was short of academically trained young people in all branches of government service. In 1965 two Fiji university graduates completed their meteorological traning in New Zealand, and returned to Nandi; however both soon left meteorology to take up administrative posts in the Fiji Public Service, one becoming in due course Governor of the Reserve Bank of Fiji. With the establishment of the University of the South Pacific at Lauthala Bay, it became easier for New Zealand to fund a bursary scheme under its Pacific Aid programme. This enabled a greater number to have academic training locally before going to New Zealand for meteorological training.

With independence, the Fiji Government accepted the responsibility for operating its own civil aviation and meteorological services on behalf of the SPATC. The ceremonial transfer of the international airport and Meteorological Service took place on 1 July 1975. New Zealand provided a new civil aviation building at the airport which housed the Meteorological Service headquarters.

Fiji did not have enough local meteorologists at the time to provide a director and a full complement of forecasters for its new Service. It asked New Zealand for help and Gabites — who had recently retired as director in New Zealand — was appointed by the Fiji Government as the first director. There were also five other New Zealand meteorologists working at Nandi on secondment. The new Service was constituted as a department within the Ministry of Communications, Works, and Tourism, later to become Tourism, Transport, and Civil Aviation.

Even though New Zealand was no longer responsible for meteorology in Fiji it still continued to operate the weather reporting stations in Kiribati, Tuvalu, Tonga, the Tokelau Islands, Niue, and the Cook Islands. Technical officers from the New Zealand Service occupied the senior posts at Tarawa, Funafuti, and Rarotonga, the localisation of these positions being disappointingly slow.

Within the SPATC, ways of replacing the air navigation charges as a contribution towards paying for meteorological services in the South-West Pacific were sought. Its twenty-second Council Meeting at Suva, in December 1978, was attended by representatives from all the Island states as well as the main SPATC partners. The council decided to recommend to its member governments that the organisation be dissolved, and that the SPATC assets

be transferred to the governments of the countries in which they were located. The vacuum left by the withdrawal of SPATC funding had to be filled because the Pacific Island weather stations were an important part of the global weather reporting network. They were unlikely to be able to operate at their current standards without outside help, so that the funding of the networks, other than in the Fiji Group, was provided largely by direct grants from Australia and New Zealand. The latter was to co-operate with Kiribati, Tuvalu, and Tonga in maintaining the existing networks.

The SPATC came to an end on 1 October 1979, and New Zealand agreed to continue to assist Fiji with staffing at Nandi for as long as required, and to train meteorologists under the bursary scheme. J. L. M. Waygood, who had not long retired as officer-in-charge of the Auckland Branch Office, replaced Gabites as director of the Fiji Meteorological Service in 1979.

In July 1981 Ram Krishna was appointed as the first Fijian director of the Service. Besides his university training in India, he had received meteorological training in New Zealand, and completed an advanced course at the University of Hawaii. New Zealand continued to provide a chief forecaster for the Nandi Office, while J. D. Coulter, a retired assistant director from the New Zealand Service, acted as climatologist for a number of years.

The number of Fijian meteorologists has increased, and in 1985 there were only two expatriate meteorologists left in Fiji. The Fiji Meteorological Service is a well equipped and competently staffed organisation. Besides its responsibilities within the Fiji Group, it provides a weather forecasting service for the other islands in New Zealand's former region of control.

Western Samoa

The New Zealand Meteorological Service handed over control of the magnetic and seismological work at Apia observatory to the New Zealand DSIR after the war, but continued to supervise the meteorological and climatological observations with one of its own observers in charge of the Samoan staff. Weather forecasts for civil aviation and the public originated in Nandi.

When Samoa became independent in 1961, it requested a continuation of this arrangement. Meanwhile, P. D. Muller a Samoan graduate from the University of Auckland, had been recruited in New Zealand to replace the expatriates at the observatory. He was trained in meteorological and geophysical observing techniques in New Zealand, and returned to Samoa in 1964.

Muller took over from V. G. Andrew, the last of the New Zealand observers, and was later appointed by the Samoan Government as superintendent of the observatory. He soon became heavily involved with the many United Nations and other aid missions visiting Apia to assist in the development

of Samoa's natural resources; and played an important part in the hydrological investigations needed to plan Apia's water supply and the water storage for hydro-electric power generation. The Samoan Government's calls on Muller's time increased and he was finally lost to the observatory in 1976 when appointed chairman of the Public Service Commission of Western Samoa — later leaving the country altogether.

The observatory celebrated its 75th anniversary in 1977 and it was appropriate that Coulter, who had served there in 1940, should represent the Service.

The New Zealand Meteorological Service continues to assist with training and advice when called upon, but has no special agreement with the Samoan Government as it has with some other Pacific states. The DSIR assists the observatory financially and provides a technical advisor in geophysics to the local superintendent. The meteorological activities are run entirely by Samoan officers who also give some assistance in maintaining the meteorological programme in the Tokelau Islands, which are New Zealand's responsibility.

The Cook Islands

The scattered islands of the Cook Group have a latitudinal spread from Penrhyn in the north, to Mangaia in the south, which is almost as great as that of New Zealand. As in some other Pacific Island nations, this has posed a problem in setting up a network of weather reporting stations and in maintaining satisfactory standards of observation. It is not realistic to expect an observer, on a small remote island without regular visits, to maintain the same standards as those of a central observatory.

Meteorological observations have been collected from nearly all islands of the Cook Group at some time or another, since the Avarua rainfall station in Rarotonga started in 1899. Daily synoptic reports from Rarotonga were received in New Zealand in the 1920s, being collected by Apia and re-broadcast. As radio communications were established with the outer islands from 1929 onwards, so other stations reported regularly.

During the war the US Army Air Corps set up bases on Penrhyn and Aitutaki, but these were closed down in 1945. The necessity of retaining a reliable network to meet the requirements of civil aviation, led the Service to station an observer, J. F. Harper, at Rarotonga in 1946. He started pilot balloon observations at the aerodrome, and by 1949 regular reports of surface observations from eight Cook Islands were channelled through Rarotonga for international distribution. At various times between 1950 and 1965, a New Zealand observer was also based on Aitutaki.

In 1950 there were plans to upgrade the upper wind observations, but

difficulties in obtaining spares for the old GL3 wind-finding radar set back the installation until 1958. A new Cossor CR 353 set replaced the GL3 in 1966, while radiosonde observations started in 1974.

In December 1978, an American funded radar wind station commenced operation on Penrhyn Island with Cook Islands staff and technicians from the Civil Aviation Division of the Ministry of Transport as operators. This was a contribution to a global tropical weather investigation and has been approved by the Cook Islands' Government to continue until 1990. One year's radiosonde observations were also made.

Training courses have been held for local staff both in Rarotonga and in New Zealand, to bring about a complete replacement of New Zealand technical officers by Cook Island employees. However, because of the losses of senior staff, and the increasing use of advanced technology, it has not yet been found possible to replace the New Zealand officer-in-charge, who remains in 1985 the only expatriate.

The contribution that meteorology can make to the Cook Islands economy through wind energy and agrometeorological studies has been officially recognised. The Rarotonga Meteorological Office is often called on to provide data or give advice to overseas experts visiting the Cook Islands. To cope with its extended function, the Meteorological Service in 1982 established a headquarters in Avarua to act as a liaison centre, while still retaining the office at the airfield.

The Tongan Group

At the end of the war the RNZAF airmen, who had been running the meteorological section at the Fua'amotu airfield on Tongatabu, were replaced by a civilian New Zealand observer. In 1951 weather observations were transferred from the airfield to the Nuku'alofa radio station, and local observers trained. The last New Zealand observer in charge, G. S. M. Smith, left Tonga in 1952 and since then the Tongan observing network has been under the control of the Tongan Government with SPATC financial support. A Tongan observer, Laitia Fifita, was in charge.

With the demise of the SPATC, the Tongan Government requested New Zealand help in maintaining the network, and entered into a similar agreement to that made by New Zealand with Kiribati and Tuvalu.

A meteorological office was again opened at the airport in 1984, and the Service transferred to the Tongan Department of Civil Aviation. Plans for upgrading the meteorological service were discussed in 1985, and it is expected that New Zealand's aid contribution, — technical advice, and assistance in training Tongan technical officers — will continue as long as

it is needed. The Fiji Meteorological Service supplies weather forecasts and tropical cyclone warnings for the Tonga group.

Kiribati (Gilbert Islands)

Under the British colonial administration, rainfall observations began at Tarawa in the Gilbert Islands in 1926. After the war and Japanese occupation, a full range of climatological observations started again at the Colony's radio station in January 1947.

New Zealand's involvement began in 1951, with the establishment of a new station on Tarawa at Betio, on behalf of the SPATC as part of the development of services for Pacific air routes. B. C. Ereckson, the first officer-in-charge, was responsible for the development and management of the weather reporting network throughout the whole of the Gilbert and Ellice Islands.

Besides setting up the main station on Tarawa, some reporting stations on the outlying islands had to be reactivated and new ones started. Gilbertese and Ellice Island observers and radio operators were trained, and then with their families installed on the remote coral atolls. Unexpected hazards sometimes arose in the process. When D. Dollimore, the second New Zealand officer-in-charge was setting up the station on Arorae in 1954, the whale boat capsized on the reef and Dollimore used the water-tight box of meteorological instruments as a canoe to reach the beach.

Although there were plans in 1950 for the installation of a GL3 wind-finding radar at Tarawa, it was not until 1973 — when an entirely new station was built — that radar wind and radiosonde observations began. The new station was a contribution to the WMO World Weather Watch programme, whose aim was to extend the global weather reporting networks. The Tarawa station was the culmination of four years of planning by the United Kingdom and New Zealand meteorological services, and was officially opened by the Governor — beginning a regular programme of upper air soundings from January 1974.

With the founding of the independent state of Kiribati in 1979, and the ending of the SPATC, new arrangements were required for the funding and management of the former Gilbert Islands meteorological programme. The Ellice Islands, which became Tuvalu on independence, split from Kiribati and a separate arrangement had to be made in their case.

Although there had been progress in training Gilbertese technical officers, Kiribati still needed technical as well as financial assistance. An agreement was signed between the governments of Kiribati and New Zealand, whereby New Zealand would fund that part of the programme previously paid for by SPATC and continue with technical assistance as long as it was required.

The United Kingdom finances the World Weather Watch upper air programme. In 1985 the officer-in-charge was still provided by New Zealand while the station's technical officer post, which initially was filled from Britain, was also filled from New Zealand. These expatriates will eventually be replaced by Gilbertese.

Tuvalu (Ellice Islands)

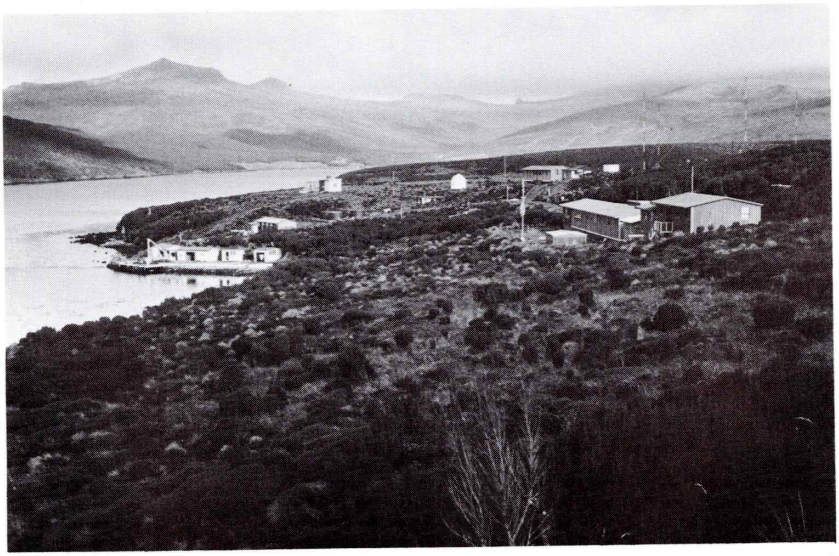
Until October 1975, when the Ellice Islands were legally established as a separate British Colony called Tuvalu, the meteorological service for the group was under the supervision of the officer-in-charge at Tarawa. With the separation of Tuvalu from Kiribati the following year, all Ellice Island meteorological staff employed in Kiribati were repatriated to Tuvalu; and the officer-in-charge of the station at Funafuti became directly responsible to the director of the New Zealand Meteorological Service for the management and control of the Tuvalu meteorological programme on behalf of the government of Tuvalu.

Climatological observations began on Funafuti in 1933. The island was chosen by the American forces for its principal base in the Ellice Islands during the war, and an airfield built. Planning by New Zealand for a radar wind station under SPATC auspices began in 1955, but it was not until October 1960 that the upper wind station was opened, with L. Rapson as the first New Zealand officer-in-charge. The then obsolete GL3 radar set, was replaced by a Cossor 353 radar in 1965.

Although at latitude 8°S, and north of the usual tropical cyclone belt, Funafuti has been struck twice by severe cyclones in modern times. The more severe on 21—22 October 1972, Hurricane *Bebe*, devastated most of the houses and coconut palms on the island. The sea wall behind the meteorological station was broached, and water poured through washing out the staff members who had been sheltering in one of the buildings. All equipment and most of the buildings were destroyed, and two of the staff lost their lives. B. Dowie, the officer-in-charge, and his remaining staff spent the night clinging to coconut palms. Meleane Pese, a meteorological observer, was awarded the Silver Medal and Certificate of Honour of the Royal Humane Society for her heroism during the hurricane. The station was rebuilt, and the new office opened in April 1975 equipped with a Plessey WF3 wind-finding radar and a radiosonde ground station.

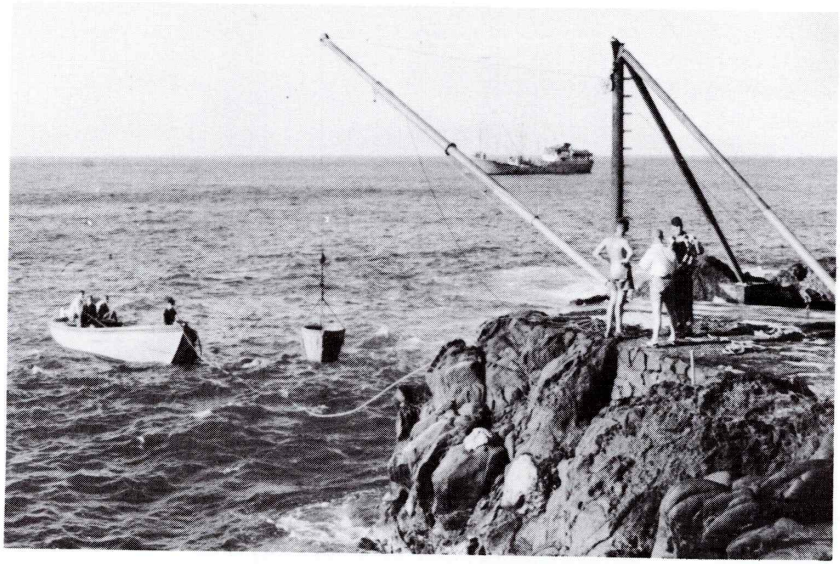
With the coming of independence to Tuvalu, and the end of the SPATC, the meteorological services were catered for in a similar fashion to those of Kiribati. The SPATC assets were transferred to the government of Tuvalu, and an agreement on financial and technical assistance signed between the

Meteorological Station, Funafuti, Tuvalu.

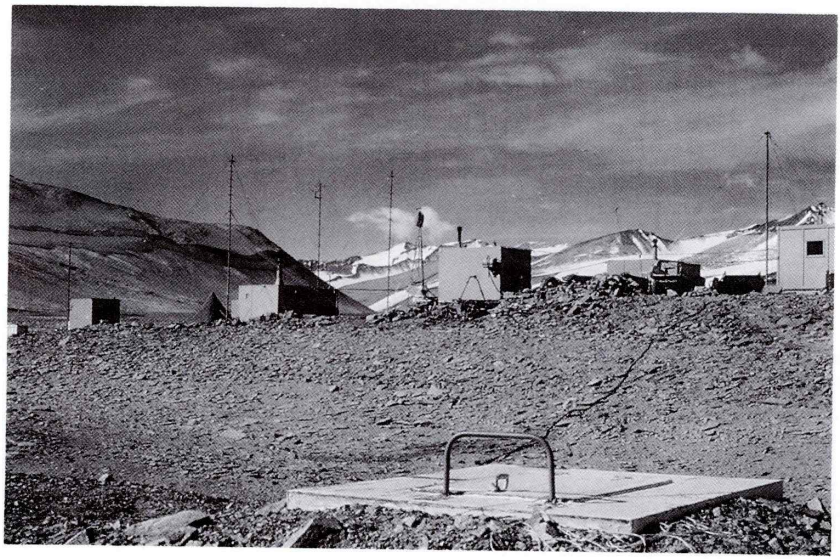


(N.Z. Met. Serv.)

Campbell Island Meteorological Station, Perseverance Harbour.



Landing stores at Fishing Rock, Raoul Island. **(N.Z. Met. Serv.)**



Vanda Station, Antarctica. **(N.Z. Met. Serv.)**

governments of New Zealand and Tuvalu. The meteorological office in Funafuti, which had previously controlled the island's power generation and telecommunications services, relinquished these facilities to the Tuvalu Government. While as in Kiribati a complete localisation of the meteorological services is the aim, it had not been achieved by 1985. The officer-in-charge and the station technical officer were provided by New Zealand. A programme of meteorological and climatological observations is carried out on each of the low lying atolls of this remote Pacific nation of about 10,000 people.

Campbell and Raoul Islands

Campbell Island in the sub-antarctic with its tussock-covered bleak windswept hills, and Raoul Island in the sub-tropics — bush covered with a central water-filled crater liable to volcanic activity — are very different environments. As isolated islands whose only human inhabitants are there for scientific purposes, and whose location makes them important weather reporting stations, they presented similar logistic and administrative problems in their establishment and maintenance — and will be considered together here.

During their war-time occupation they were both administrated by the Public Works Department. In 1951 control of the meteorological stations was passed to the Civil Aviation Branch of Air Department, and more recently to the Ministry of Transport. After the withdrawal of the coast watchers from Campbell Island, Barnett made a strong plea for its continued occupation as a weather reporting station, and this was supported by the DSIR whose interest was in ionospheric observations, and by the directors of the Dominion and Canterbury Museums. Cabinet approved another year's activity at Campbell Island in November 1945, and this was later extended for yet another year to become accepted as a permanent arrangement. In 1948 meteorological observer positions were established for the two islands and the tour of duty fixed at twelve months.

From 1937 to 1952 the observations at Raoul Island were made by the post and telegraph radio operators who were joined by the first meteorological observer, L. Rapson, in 1948. When radio telephone communications replaced the use of morse the operators were withdrawn from the island.

The logistic problems of servicing these remote islands have always been considerable. For the first few years after the war, the Royal New Zealand Navy was called on every six months to provide shipping. The Korean War prevented the continuation of this arrangement, and in 1952 the Holm Shipping Company began its long association with Raoul and Campbell Island, servicing on an annual basis. The loss off the Canterbury coast of the MV

Holmglen with its crew in 1959, a few days after completing the Raoul Island servicing, was a severe blow to the Company and the servicing programme. For many years the *Holmburn* was the mainstay of the annual provisioning of both islands.

Over the years there have been a number of occasions when emergency shipping had to be found at short notice to take off expedition members for medical reasons. On 23 November 1964 the whole expedition, together with a visiting party from the Ornothological Society of New Zealand, was taken off Raoul Island by HMNZS *Lachlan*. For some time prior to this, the Island had been shaken by a swarm of earthquakes, and on 21 November volcanic activity started in the crater. A vulcanologist from New Zealand flew over the Island and as the *Lachlan* — which had been diverted back to Raoul Island after dropping the ornithologists — could not remain indefinitely, a decision was made to evacuate everyone back to New Zealand. Thirteen days later the *Lachlan* returned with the nine member 1964—65 expedition. There was no renewal of volcanic activity, and the party continued the scientific programme. The island has a long history of seismic and volcanic disturbances, but there has been nothing as severe as the 1964 incident since then.

At both Raoul and Campbell Islands unloading the stores has been a strenuous and sometimes hazardous business: everything was carried ashore in the ship's boats. At Raoul Island men and stores were lifted in a basket swung from a derrick at Fishing Rock, the exposed landing place, and the stores taken to the top of the cliffs by a flying fox for the three kilometre transport to the camp. Although the unloading at Campbell Island did not have the same problems, it had its own peculiar difficulties and the transfer of 600 drums of diesel fuel by open boat was often a hazardous occupation.

There have been improvements. In April 1980 four large fuel tanks were installed on Campbell Island to hold 14 months' supply of diesel oil which is now pumped from the ship to shore. At Raoul Island, the swinging basket and flying fox are sometimes avoided by the use of a helicopter for the unloading.

After the Holm Company disposed of the MV *Holmburn* in 1974, there was great difficulty in finding a suitable substitute capable of carrying both the stores and the ten or so passengers of the relief expedition. The Stewart Island Ferry *Wairua* was used to service Campbell Island, but because of limited cargo space needed three trips a year. For Raoul Island two ships were required, the MV *Holmdale* to take the cargo, and an RNZN frigate the passengers. These arrangements are inefficient and expensive. They are able to be replaced using specially constructed removable accommodation secured to the deck of the *Holmdale* when the vessel is used for servicing

the islands. This provides accommodation for twelve people, and when not in use is kept in the Ministry of Transport's store. However it is not always possible to use the module, and transport to both islands remains uncertain and expensive.

The expense of maintaining these island stations is about 15 per cent of the total expenditure of the Service, and has often made them targets of official cost cutting exercises. There have been suggestions that the scientific programme should be curtailed or shut down altogether. The Cabinet Committee on Expenditure suggested in 1976 that the Raoul and Campbell Island stations could be replaced by annually serviced automatic weather stations, communicating via satellite. The political arguments against leaving unoccupied these outposts of New Zealand's maritime economic zones, together with their importance in the international meteorological network, have been sufficient to save them. The meteorological programme at Raoul Island however, has been reduced.

Both stations carry out a programme of surface and upper air observations. Radiosonde observations started at Raoul Island in 1952, and stopped in 1980. Radar wind flights did not begin until October 1973 using a Plessey WF3 radar set.

When in 1955, United States aircraft of operation 'Deep Freeze' began to fly to the Antarctic, weather reports from Campbell Island assumed an added importance. As New Zealand had no immediate plans at the time for the installation of radar wind equipment, the Americans made a radio theodolite set available in 1960. Staff at Campbell Island were increased during the summer months to enable extra wind soundings to be made. Regular radiosonde flights began at Campbell Island in 1957.

Although the primary purpose of the two stations is to provide meteorological observations, there is an important geophysical component in the scientific programme, and there are also frequent visits by biologists. Each year such extra projects as can be fitted in by existing staff are carried out on behalf of the DSIR, universities and museums, and many meteorological technical officers have become adept at bird banding and assisting in other scientific disciplines.

At both islands the camp consists of a substantial cluster of workshops, laboratories, and stores besides the main hostel. The first Campbell Island camp was, by the nature of the expedition's coast watching duties, located in a secluded site in Tucker Cove. Living conditions were basic and the site was not suitable for an expanded post-war scientific programme. A new camp was built on the lower slopes of Beeman Hill at the head of Perseverance Harbour, and formally opened by Dr Barnett in 1958. Since then it has been

added to, and in 1975 a twelve-bunk extension was contructed for the use of visiting scientific parties.

There were early and not very successful attempts at Campbell Island to grow vegetables to supplement the diet. In 1953 Dr Simmers began the present practice of sending seedlings to the Island each year in small cardboard pots for replanting under glass.

At Raoul Island the more favourable conditions, and the presence of about twenty Niue Islanders employed at the time on the building of a permanent camp, led to the establishment of a farm in 1948. For many years a farm manager was included in each expedition, and the farm was a flourishing concern and a centre of interest for the whole station. However with the introduction of more efficient and large refrigerators, the economics of the operation could not be justified and from 1973 the farm was gradually run down.

Antarctica

The world scientific organisations, including the World Meteorological Organisation, designated 1957 as an International Geophysical Year (IGY). This co-operative venture was aimed at extending the understanding of the global physical environment, including the atmosphere. Special efforts were to be made to gather co-ordinated observations of geophysical and meteorological phenomena over as much of the earth as possible. The announcement of an IGY stimulated a renewed interest by New Zealand in the Ross Dependency in Antarctica, over which it claimed jurisdiction, and in September 1953 the Antarctic Society wrote to the prime minister urging the government to give serious consideration to establishing a scientific base in the Ross Dependency, to be in operation in time for the IGY.

The Royal Society of New Zealand set up a National Committee for the IGY, under the chairmanship of Barnett, to prepare a tentative New Zealand scientific programme. Antarctic research was not included in the recommendations, because the committee thought that New Zealand did not have the necessary facilities.

However in 1954 the International Council of Scientific Unions sought the assistance of the Royal Society of New Zealand in encouraging New Zealand participation in the IGY, to run from July 1957 to December 1958. Government approval was eventually forthcoming and resulted in the construction of Scott Base on Ross Island in McMurdo Sound. Government and private contributions made possible New Zealand's trans-Antarctic Expedition. At that time the last Meteorological Service involvement in the Antarctic had been the service by Simmers with Mawson's two expeditions in 1929-31.

The United States planned to put considerable effort into the Antarctic sector of its IGY prgramme, and in the new year of 1955 the icebreaker *Atka* called into Wellington on its way south to prospect for American Antarctic bases. New Zealand was the staging post for a succession of icebreakers, picket ships, and later aircraft when Christchurch became the New Zealand headquarters for American activities in the 'Deep Freeze' operation. New Zealand-American co-operation in the Antarctic became very close and New Zealand was to depend on the United States almost entirely for both transport to the Antarctic and within Antarctica itself.

The US Army Air Force established a small weather forecasting unit at Christchurch in October 1955, to service 'Deep Freeze' aircraft flying to the Antarctic. At the Little America base in Antarctica, M. Rubin of the US Weather Bureau set up a 'Weather Central', which was to be the main IGY weather analysis and forecasting office for the Antarctic. E. G. Edie, a senior meteorologist from the general forecast office, Wellington, spent the summer of 1956-57 as guest scientist at the Little America 'Weather Central' assisting with its establishment. During 1957, current weather reports from Antarctica were received in Wellington for the first time.

Although the Service did not have a representative on Sir Edmund Hillary's trans-Antarctic Expedition, Dr R. W. Balham, a former Meteorological Service observer who had served on the Cape Expedition as meteorologist and coast watcher, was the biologist-meteorologist with the 1956-58 winter party.

Scott Base was completed in time for the IGY and from its beginning there was a meteorological observing programme. In its second year D. C. Thompson of the Service was seconded to the DSIR as senior scientist at the base, starting micro-meteorological observations.

After the close of the IGY, the New Zealand Government agreed to maintain Scott Base, and to fund its share of Hallet Base, a joint US-NZ enterprise. Overall control of New Zealand's Antarctic scientific programme was to be exercised by a Ross Dependency Research Committee (RDRC) set up in 1958 to advise the minister in charge of the DSIR. Since then, proposals for Antarctic research projects from government departments and the universities, and requests from New Zealand scientists to work in or visit the Antarctic have required RDRC approval. Simmers was appointed chairman of the RDRC, and since his time the director of the Meterological Service has always been a member.

During the IGY the large ice-free areas in Victoria Land north-west of Scott Base, were investigated by a four-man team from New Zealand. Because of the continued New Zealand scientific interest in the area, the RDRC planned to establish a temporary station there, and in 1966 Lake Vanda was chosen

as the site. The reasons for the ice-free nature of the valley, and the physics of the lake — with its four-metre thick ice covering and warm bottom waters — made interesting scientific problems. Thompson supervised the planning of a meteorological programme to record the incoming and outgoing radiation, and the wind and temperatures at several levels, both in the free air and below the surface. The camp was built near the lake in a narrow barren valley, enclosed by mountains rising to 2000 m. Government approval was obtained for a wintering-over party to occupy the base in 1969. R. F. M. Craig, a meteorological observer, was appointed the meteorological specialist in a five-man team. Since then Vanda Station has been occupied mainly by summer parties and a number of meteorological staff have served there. None has equalled the record of A. M. Bromley who wintered over twice and spent a summer season there. He was awarded the Polar Medal.

Although meteorologists have not been included every year in the Scott Base party, many members of the Service have spent some time working there on special projects. High quality, routine weather observations have been made continuously since the base was established.

The Service was given another opportunity for Antarctic experience in 1975, when the United States National Science Foundation asked for New Zealand participation in the meteorological programme at the Scott-Amundsen Pole Station. Approval was given for a technical officer to go to the Pole for a year's tour of duty and for a meteorologist to join him for the summer only. The principal duties were the twice daily radiosonde observations, and surface weather reports. There were also other special meteorological programmes — radiation, micrometeorology, base-line air pollution studies, and monitoring trace substances in the atmosphere. The joint arrangement continued until November 1978, when the National Science Foundation again took over the whole Pole Station programme.

8

The computer revolution and automation

The possibility of fully integrating computer methods into the operations of the Service became a reality in 1977 when a contract was signed for a computer installation exclusively for Meteorological Service use. For the preceding twenty years the Service had used data processing equipment belonging to other organisations, and had spent considerable effort justifying to the necessary authorities the benefits a dedicated computer would bring to meteorological science and its applications in New Zealand.

Despite the justifications, it was government policy during the 1960s to provide large computer centres only where these would be used by a number of government departments. While this was acceptable to most, the application of the computer to the processing of data for weather map analysis and weather forecasting required access to the machines at fixed times each day on every day of the year. This could not be guaranteed by a central bureau and it was years before the unique requirements of the Service were officially recognised. Even after recognition it was the promise of financial savings in the operations of the Service that finally brought approval for a meteorological computer installation.

In 1957 a start was made to transfer climatological data to punched cards by the mark sense system, processing it on machines belonging to the Treasury. The same system was used at the branch offices of the Service for recording back-data and the current hourly synoptic weather reports. This continued until 1980 when a change was made at the branches to computer derived recording. The mark sense system proved to be an effective and low cost way of recording data and was ideally suited to the time.

By 1960 punched cards for the data file were being produced from the teletype communications paper tape, and by these indirect means about 120,000 cards a year were accumulated. This was soon increased by direct card punching. Processing of the cards on the Treasury computer was also

begun at this time to give climatological summaries of upper winds and temperatures.

Numerical weather prediction

Simultaneously E. A. Williamson began to use computer techniques to analyse upper air charts, and forecast large scale flow in the the middle atmosphere of the New Zealand region. These experimental trials were gradually refined and by 1966 the Service had a very modest numerical weather prediction programme.

The calculations were done on an Elliott 503 computer operated by the applied mathematics division of the DSIR. Once a day on a five day a week basis they gave a 24-hour forecast at the 500 mb (about 5000 m) level together with forecast winds at this level for aircraft use. The initial data for the calculations were extracted by hand from the manually produced National Weather Forecast Centre (NWFC) weather maps and fed to the machine by punched cards. Later these cumbersome methods were replaced by the automatic extraction of the data from the teletype paper tapes of the incoming reports. An improved atmospheric model gave 24-hour forecasts of the large scale flow patterns together with the upper winds and temperatures at two levels, over an area which included the international air routes of the South-West Pacific.

The computer products were provided as guidance material to the forecasters in the NWFC and to the branch offices. The mathematical simulations used in the calculations were very simplified representations of the atmosphere and there were large ocean areas with no upper air observations. The gaps were filled for computational purposes, by 'bogus' reports estimated by the forecaster.

The meteorologists in the NWFC used the computer products as one forecasting aid, and had to learn when unexpected developments thrown up by the machine were the result of deficiencies in the model or lack of observations, and when they were genuine.

The computing facilities available did not permit the operational use of the more realistic atmospheric models which were in common use in some meteorological services. However, work proceeded in the research section on developing a more advanced model for future use.

In 1972 a computer terminal installed at Kelburn gave direct access to the government computer centre and, while this did nothing to improve the position for operational weather forecasting, it greatly assisted the data processing for climatology and the testing of research programmes. Programmers

were appointed in 1964 and by then the Service had its own punch card operators.

Struggle for the Service's computer

The State Services Commission had been convinced by 1973 that terminal facilities to the government computer centre were unsuitable for the operational needs of the Service, and helped prepare a proposal for a small computer solely for meteorological use. This was turned down by government and for the next two years the Service presented various proposals to the State Services Commission, the Treasury and cabinet committees, but failed to get the necessary approvals.

In the meantime several factors made it clear that without adequate computing facilities the Service would probably be unable to retain the trained staff needed to carry out statutory functions. It would certainly be unable to take advantage of the flood of information which the new meteorological satellites had begun to provide.

Manual methods of data preparation had begun to have a serious effect on the technical staff in the NWFC. The incoming data for weather forecasting required a large Civil Aviation communications staff to tend the teleprinters. The meteorological observers were responsible for filing the reports, assembling the coded messages for onwards transmission to different uses, plotting the observations on numerous maps and charts, and copying forecasts — all of which required tedious paper shuffling. About half a million figures a day were processed by hand in the NWFC. The monotony of much of this work brought an annual turnover of 70 per cent in the basic grade staff compared with 10 per cent for similar staff in other branches of the Service.

The prospects for retaining professional officers were also far from bright. After the lean years of the 1950s and early 1960s the Service had begun to recuit some able young scientists, several of whom had been sent overseas for post-graduate study. If the Service could not provide the modern facilities common elsewhere, their qualifications would enable them to find positions where there was more job satisfaction. The resulting loss of staff and collapse of morale could affect the ability of the Service to do its job.

From the early 1970s the Meteorological Service, in common with other government departments, was subject to cost cutting exercises and a gradual attrition in staff numbers known as the 'sinking lid' policy. Staff limitations were however accompanied by an increase — and not a falling off — in the demands for meteorological services. During the financial paring exercises, the Service was able to show that the installation of a computer in the NWFC

would enable substantial long-term savings to be made in running costs. They would be effected by a streamlining of the telecommunications systems and data handling, with consequent staff savings. Also, the activities of the very expensive Raoul Island station could be reduced. Meteorological satellites provided upper air temperature data, which could to some extent replace the radiosonde observations at Raoul Island. This was dependent on an upgraded satellite station and a computer to process the data. The long term savings would outweigh the extra expenditure.

Another argument in favour of according urgency to the Meteorological Service case for a computer was the impending retirement of the applied mathematics division machine which was due to cease operation in January 1978. Without a computer dedicated to the needs of the Service, its numerical weather prediction programme would stop, if only temporarily, and certainly could not be extended to its full potential.

The cabinet committee on the State Services noted the promised financial savings and in July 1977 approved the expenditure of $600,000 on a mini-computer for the Meteorological Service. It was possible at last for the Service to join the rest of the developed meteorological world, and the ensuing changes which took place in a relatively short time, affected every part of its operations.

The computer system chosen was a dual Digital Equipment Corporation PDP 11/70. One of the processors was solely for the NWFC operations while the second was primarily a backup. Continuous computer availability had to be guaranteed once the planned changeover from manual to machine methods was made. A shut down of more than six hours was unacceptable because of the problems caused in those industries requiring continuously updated weather information. Aviation is particularly vulnerable.

When not needed as a NWFC backup the second processor was available for the development of the operational systems to run the facility, for research purposes, and as a remote entry link to the government computer centre near Wellington. This centre with its ICL 2980 computer was opened at Trentham in 1977 and was the largest of the five centres owned by the Computer Services Division of the State Services Commission. It served as a data processing centre for eleven government departments. The Meteorological Service, through its own remote terminal, used it for archiving climatological data and for most of its climatological and research data processing.

The Meteorological computer facility was planned to:

- receive and process meteorological reports of all types via the Aeronautical Fixed Telecommunications Network (AFTN)and act as a fully

backed-up communications centre, in effect virtually replacing the existing civil aviation communications centre at Kelburn.

- receive and process data from meteorological satellites via the new satellite receiving equipment, thus providing cloud pictures, measurements of sea surface temperature, and upper air soundings of temperature and humidity.
- interrogate up to forty automatic weather stations, receiving the information via the Post Office telex system.
- run simple numerical weather prediction models, using data collected in real time (as soon as possible after observation time), with the outputs going to an automatic map plotter.
- automate much of the manual data processing in the National Weather Forecast Centre.
- provide a remote job entry communications link to the ICL 2980 computer at the Trentham Computer Centre where all meteorological data are archived and some research processing done.

The installation of the first units began in May 1978 and the system became partly operational by September; since then all six functions above have been fully implemented.

The operations of the NWFC are now wholly dependent on the computer which receives and processes data. Tedious manual work has been largely eliminated, releasing both technical officers and meteorologists for more productive tasks. The fifteen communications staff which formerly tended ranks of teleprinters have been reduced to three following the automation of the AFTN. Most of the incoming coded weather reports still arrive via the AFTN but now go directly into the computer, which also carries out some error detection procedures.

The data files contain meteorological reports of surface and upper air observations from land stations, ships, and aircraft; from buoys drifting in the southern oceans; and temperatures, humidities and winds estimated from satellite data. The data coverage extends from the Indian Ocean in the west to the central Pacific Ocean in the east, and from just north of the equator to the South Pole.

The mass of information is sorted for a variety of users and approporiate lists printed. Some of the surface reports are still plotted manually on weather maps for analysis by the forecaster. Upper air observations are mostly plotted automatically on a flat-bed plotter and the maps are machine analysed.

Wellington is a regional centre of the WMO Global Telecommunications Service. The collections of reports it is obliged to make available inter-

nationally, are automatically assembled and sent over the AFTN to the Pacific and to Melbourne for onwards transmission to the rest of the world.

Computer predictions of large scale flow patterns for up to 48 hours ahead are produced much more readily than previously, while the satellite derived information fills in the formerly data-blank areas. From the incoming data, the heights of seven pressure levels (from near the surface to a height of about 16 km), are found over a grid of 800 regularly spaced points, covering a third of the Southern Hemisphere. Simplified forms of the equations governing atmospheric motion are used to produce predictions, and contour maps of the analyses and forecast charts are drawn by the plotter.

The PDP 11/70 is not large enough to use the more realistic and complete forms of equations used by larger meteorological services. This means the simplifying assumptions limit the accuracy of computer predictions, but they are still a valuable guide to the forecaster. The accuracy of these predictions is considered in the next Chapter.

Forecast winds and temperatures for levels required in airline planning come directly from the computer predictions. The numerous weather forecasts produced during each day are entered directly into the computer, being edited and transmitted automatically to the airline's computer.

The considerable amount of systems analysis and programming for all these applications was developed locally, mainly by the three meteorologists and two programmers assigned to the project.

There are some nineteen visual display units in the Kelburn building, linking into computer facilities and a steady increase in workload has led to the installation of additional features to optimise computer efficiency. Even with these, the present Meteorological Service computer is a very heavily loaded machine.

Data Processing

Since 1957 the Service has archived meteorological data on punched cards and magnetic tape, and has produced a variety of climatological summaries using machines at a succession of government computer centres.

Over 1000 million characters of weather data are currently stored on some 300 magnetic tapes at the Trentham centre. There is an annual increase in stored data of over 150 million characters: this comes from the observations made specifically for climatological purposes and those which flow daily into the NWFC for weather map analysis and forecasting. These daily observations are held on disc storage for six weeks and then transferred to the magnetic tape archives. The Trentham centre also contains approximately

300 programmes for maintaining and processing the various data sets. The files are kept up to date, data checked and routinely analysed.

The Service is the national store of meteorological data. From the archives, data are reproduced for many organisations requesting sets of observations. Typically these requests come from government departments and universities within New Zealand as well as overseas organisations. If required these can be readily supplied on magnetic tape for processing on other computers.

The future

The relatively small PDP 11/70 computer has served well, and in combination with access to the larger machine at the Trentham centre has completely changed the operations of the Service. However there are limitations to the system and approval has been received for an upgrading of the computer facilities and the installation of small computers at the Weather Centres at Auckland and Christchurch. The greater computing power will then allow the operational use of the advanced forecasting models developed by the research section and the processing of more satellite data. Data which have a direct application to the fishing industry, water resource management, and agriculture, are at present not being fully utilised.

The immediate future will see an increase in the number and sophistication of meteorological probes whose observations will require computer processing. There will be a greater use of data loggers and automatic weather stations. Observation from drifting buoys, ships and aircraft relayed through meteorological satellites are already a reality and the volume of such information is bound to grow. The Service should be well placed to take advantage of the additional data.

9
Weather Forecasting

By early 1946 the RNZAF weather forecasting units had been withdrawn from the Pacific, except for those in Fiji and Western Samoa where they had been reduced in size. Within New Zealand, forecasting offices were retained at Auckland (Whenuapai and Mechanics Bay), Ohakea, Wellington (Rongotai and Kelburn), Christchurch (Wigram) and Taieri. As the staffing position deteriorated several of these were later closed. Only at Mechanics Bay and Kelburn was a 24-hour, seven day a week forecast service provided. In Fiji the forecasting unit was shifted to Nandi when New Zealand took over from the Americans there in 1947.

The lifting of the war-time restrictions on the public dissemination of weather information brought back the radio weather forecasts. The return to a civilian basis allowed the Service to put greater emphasis on providing special weather forecasts tailored to the requirements of the user. By the early 1950s a number of organisations were receiving weather information on a regular basis. For instance, the forecasters had daily discussions with the load dispatcher of the State Hydro Department at Hamilton to assist in the most economical scheduling of power generation for the following twenty-four hours. There were forecasts of fire risks for the Forest Service, of heavy rainfall for catchment boards, of cloud cover for the New Zealand Aerial Mapping Company, and special forecasts for many other concerns.

The demands from the civil airlines for reports and forecasts increased (in 1948 it rose by about 20 per cent) and with higher flying aircraft greater attention had to be paid to upper level conditions. The DC6 aircraft were flying to 17,500 ft (5000 m) so upper level charts for 500 mb had to be drawn regularly, though the paucity of upper air data was a considerable handicap. By 1952 upper level charts to the 300 mb level were being constructed at Nandi, Auckland and Wellington. Nearly all the Pacific forecasts for the overseas routes in the New Zealand area of responsibility were issued from Nandi and Auckland.

The Service also had the responsibility for meeting the meteorological requirements of the peace-time RNZAF. But because of staff shortages the forecaster positions at Lauthala Bay, Whenuapai, and Ohakea remained

vacant. Only at the RNZAF base at Wigram could the needs of the air force be completely met.

Another change in meteorological requirements came when jet aircraft appeared on the Pacific routes in 1959, with a QANTAS Boeing 707 service from San Francisco to Sydney via Nandi. To work out forecasting procedures for the jets a conference was held in Wellington in May 1959. These were based on guidelines for meteorological services to aviation as laid down by the International Civil Aviation Organisation (ICAO) which has close ties with the World Meteorological Organisation.

Centralisation of aviation forecasting

The introduction of computer methods and the reception of satellite cloud pictures was accompanied by an increasing centralisation of weather forecasting services for aviation. Because many of the new technological aids were located in Wellington there was a corresponding concentration of scientific staff. In order to make the most efficient use of the new equipment the ultimate goal was to centralise many of the forecasting services. A parallel change to raise the standard of training for technical staff enabled them to be more effective interpreters of the products issued by the National Weather Forecasting Centre. Traditionally technical staff were the main contact with the public at the smaller branch offices but with increasing sophistication in the Service their range of duties had expanded to take over some of the meteorologists duties. Centralisation took place in a number of stages.

In 1969 the Australians suggested that individual flight forecasts for international flights should be replaced by route or area forecasts which would be routinely updated. There were discussions with New Zealand aviation and meteorological authorities and the scheme was taken up by ICAO. It was approved at the 1973 ICAO Air Navigation meeting in Honolulu, and New Zealand undertook to establish an area forecast centre in Wellington for the region from the equator to latitude 40 °S and longitude 145 °E to 145 °W.

Air New Zealand decided in late 1974 to introduce computerised flight forecast planning for all its routes and requested forecasts of winds and temperatures at flight levels averaged over five degree squares of latitude and longitude. The system was extended to cover most of the South Pacific air routes and until computer forecasts could be produced regularly for the whole area, manual methods of estimation were used. Nandi supplied the data for the tropical squares north of latitude 25 °S and Auckland for south of that line.

Aviation forecasting for the domestic flights was centralised by setting up

a special section at Wellington Airport which in 1975 was transferred to the NWFC at Kelburn. The integration of the Meteorological Service computer into the NWFC operations completed the centralisation of aviation forecasting.

From September 1980 Wellington became an ICAO area forecast centre, one of seventeen similar centres around the world providing route weather conditions and other relevant flight information for international aviation. This involved being responsible for the whole of New Zealand's Pacific forecast area, and every six hours giving winds and temperatures for both 12 and 24 hours ahead for the airspace above the 500 mb level (about 5500 m). Manual forecasts of *en route* significant weather and aerodrome weather forecasts supplemented the computerised information. The format supplied was suitable for computer flight planning by the airlines. In the forecast room a special aviation monitoring section kept a constant watch on the credibility of all the weather information sent to and received from aircraft.

Centralisation and the computer age brought a complete change in the place of the Auckland branch office. From the late 1930s it had been intimately connected with the growth of aviation and especially with trans-ocean flying. L. N. Larsen, who had been in charge from 1939 until his retirement in 1973, fostered excellent relations with the aviation industry. He flew on the first Tasman Empire Airways flying boat survey flight from Auckland to Sydney in 1940 and with the RNZAF Hastings aircraft in the London to Christchurch International Air Race in 1953. He and his senior staff spent most of their careers in the Auckland office, which because of its specialised function became an almost independent enclave in the Service.

From the original office in a three-metre square anemometer hut at the RNZAF base at Hobsonville, the Auckland branch had a number of locations around the city. During the war it was part of the Northern Group headquarters for the New Zealand Army, Navy and Air Force, supplying forecasts for the operational airfields in the north of the North Island and for all operational aircraft movements from New Zealand to the Pacific area. These included the ferrying of fighter, reconnaissance, and transport aircraft on routes to Australia, New Hebrides, New Caldeonia, Fiji, the Solomon Islands, and Canton Island. A great number of the forecasts were for the American forces. The US Navy aerological unit was fully integrated with the Auckland staff as was the USAAF unit at the RNZAF base at Whenuapai. At its peak there were 115 meteorological staff under Auckland control.

After the war, although there were increasing demands for meteorological information from the industry and the Auckland public, the office remained largely aviation oriented. It provided all the forecasts for international aviation operating from Auckland. However technology, allowing centralisation of

services, altered all that. The computerised area forecast system was relocated to Wellington, taking with it the responsibility for international aviation weather forecasting. The Auckland branch office then became the Weather Centre for New Zealand's largest city.

The type of weather service required by international aviation became more impersonal with the introduction of each new generation of aircraft. The days of the detailed briefing and debriefing sessions with the flying boat crews at Mechanics Bay were long past. The automatic transmission of flight information from the meteorological computer to the airline's computer completed the process.

Centralisation in weather forecasting for international aviation was taken beyond the bounds of New Zealand when ICAO replaced the individual area forecast concept by a global scheme. After consultation between international aviation and the meteorological agencies in June 1983, the ICAO council adopted a fully integrated 'world area' forecast system. Its aim was to supply the world's meteorological authorities and aviation users with *en route* weather information on winds, temperatures, and tropopause and significant weather, in both pictorial and printed form through a globally uniform system. Two world centres were established in Washington and London, with fifteen regional centres set up, including Wellington.

The world centres produce global forecasts twice a day. These are sent to the regional centres which process the information into bulletins, route forecasts, and charts appropriate to users in their area. The regional centres are responsible for any amendments to forecasts, and for preparing significant weather warnings. The Wellington centre has been given the oversight of the Pacific countries from Vanuatu to French Polynesia in an east-west direction, and to Kiribati in the north. Wellington became operational in 1985, being the first operational Regional Centre in the Southern Hemisphere. The Wellington Centre is responsible for the forecasts for its own national airline and provides meteorological information for all Air New Zealand flights including those to northern hemisphere destinations.

The full global implementation of the ICAO plan depends on the provision of adequate communications and computer facilities at each of the regional centres. The ultimate in centralisation — which although proposed is at present very far from realisation — would be the phasing out of the regional centres. The whole of the weather forecasting services for international aviation would then be provided by one or two World Centres.

The processes which led to the elimination in New Zealand of the Auckland branch office from aviation forecasting are at work on a global scale. How far the process goes depends on a whole range of political and technical

factors. It is obvious that the role of a national weather service in a small country such as New Zealand is bound to change in the future.

Public forecasts

In spite of radio and television becoming a more immediate means of giving the public up-to-date weather information the format of the forecasts given in the newspapers remained unchanged from the end of the war until 1979. The reproduction of weather maps started in 1946 in the four main centres, with the maps being supplied by local weather offices. A coded version was sent to the paper where newspaper staff reconstructed the original map. This scheme was later extended to the provincial papers, starting with New Plymouth in 1955.

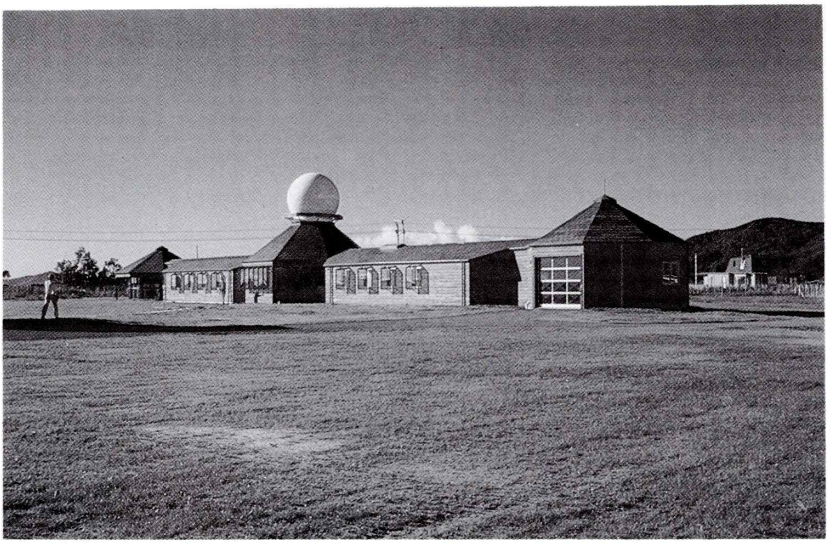
By 1977 sixty per cent of newspapers published weather maps, most drawn by the papers' own staff. In 1985 nearly all papers included weather maps, but by then most maps were transmitted from the NWFC by facsimile. The traditional short range forecast for districts in the newspaper's circulation area were still printed, but accompanied by a variety of other weather information from both New Zealand and overseas.

Television forecasts started in 1961 and initially were limited to static displays because of staff and equipment shortages in the television service. The first live presentation in March 1962 from Wellington used television service personnel, and at first departures from the prepared scripts sometimes produced puzzling forecasts.

The Service's own forecasters were not used until July 1981 and there are now two different national presentations as well as those from the regions. The professional meteorologists have been able to add topical comments on daily weather events within their allocated time slot of under two minutes. The television presentations have had an enormous influence in raising the interest and awareness of the public in the weather and the forecasting side of the work of the Service.

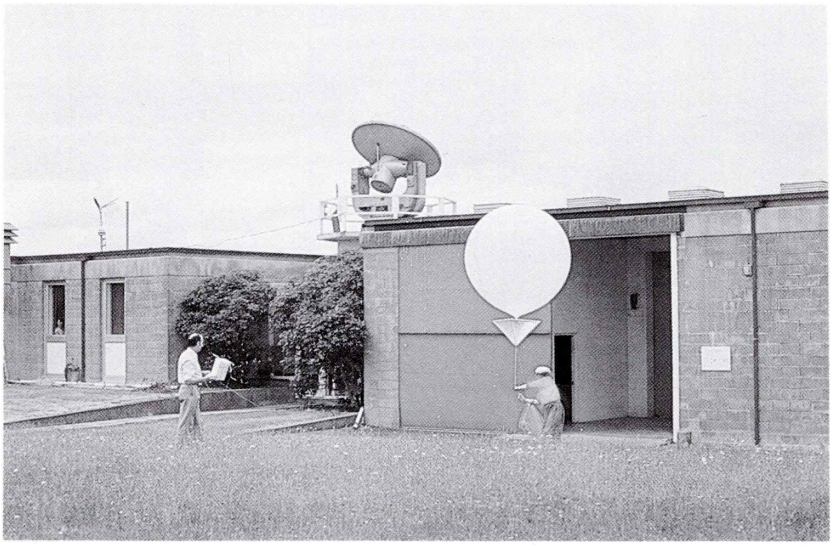
While television is the most striking means of bringing weather information to the public, the use of radio has also extended and changed. The number of direct broadcasts from Kelburn has decreased while local and regional weather services have been extended. There are also more specialised broadcasts for leisure activities such as skiing, tramping and boating. Immediate short term forecasts became available in the main centres through the telephone automatic weather forecast system which was installed first in Auckland in 1965 and afterwards in other centres.

The most recent technological innovation in communicating weather information to the public came with the introduction to New Zealand of Tele-



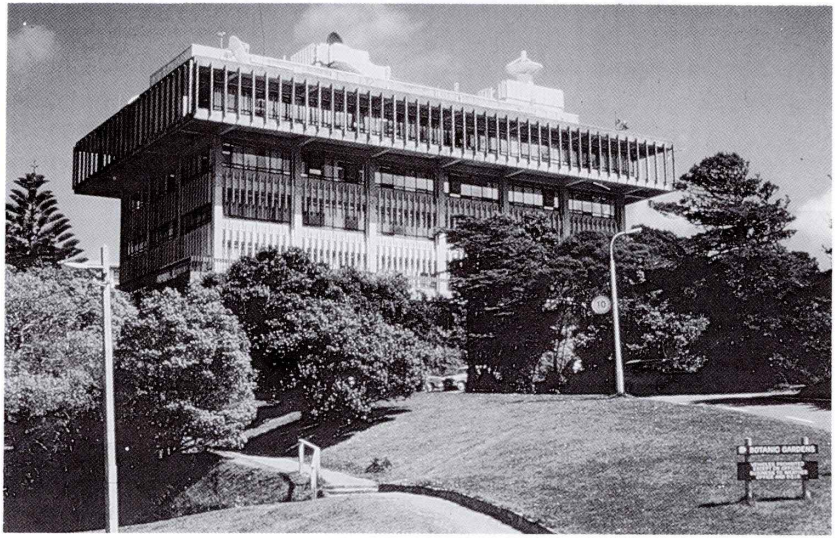
(N.Z. Met. Serv.)

The Kaitaia Observatory, opened 1985. Radar dome in centre of main building.



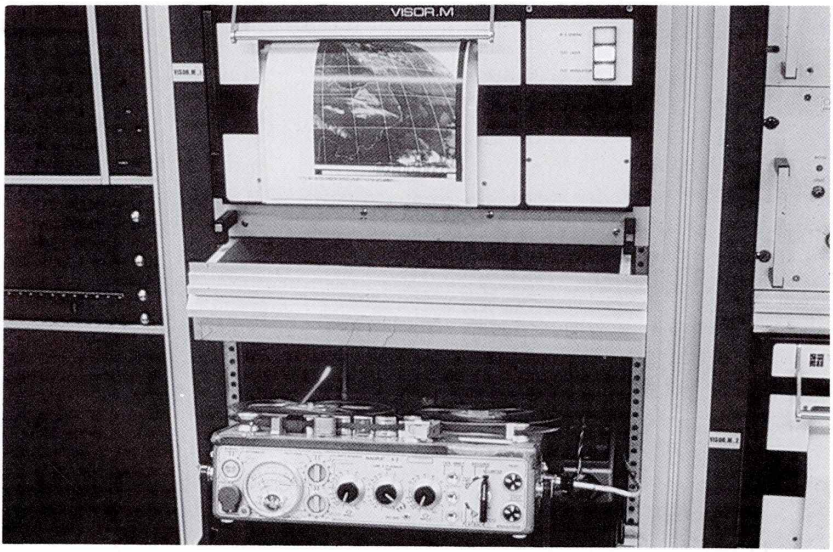
(N.Z. Met. Serv.)

Radiosonde balloon being released at Auckland Airport, 1984.



(N.Z. Met. Serv.)

Head Office of the New Zealand Meteorological Service, Kelburn, Wellington opened 2 April 1968.



(N.Z. Met. Serv.)

Computer generation of a satellite picture.

vision New Zealand's Teletext service in February 1984. The Meteorological Service supplied each day district, coastal, and mountain weather forecasts, plus rainfall and temperature information for 46 places. All the routine public forecasts are sent to the Teletext centre as they are issued, and the information is regularly updated. The Videotext system using Post Office lines, which was introduced later, is more comprehensive and can give the viewer almost limitless information. It is also supplied with meteorological reports and weather forecasts. There is a wide range of ways in which weather reports and forecasts can now be channelled to the public and the 'viewdata' systems give specialised users the means of receiving up-to-date meteorological information tailored to their needs.

One of the most important functions of the Service is to give warnings of severe weather conditions. As much advance notice as possible is required both by those organisations which may have to initiate emergency action and by the general public. Any weather conditions which may directly, or indirectly, cause loss of life or human injury, stock losses, or damage to property or crops are a matter of concern. Emergency warning systems have been set up to inform the appropriate agencies. The responsibility for assessing the likelihood of flooding and for issuing warnings rests with the catchment authorities and not with the Meteorological Service, whose role extends only to the forecasting of heavy rainfall.

Until 1978 weather forecasts for shipping and for the coastal waters were provided either by the NWFC or the Auckland branch office. With off-shore oil exploration and the erection of the Maui platform off the Taranaki coast forecasting the state of the sea assumed greater importance. For the erection of the platform the expected meteorological, wave and swell conditions were provided by an overseas company. They sent a meteorologist to New Zealand who collaborated with the forecasters in the NWFC, to provide weather forecasts for the construction period.

In 1978 the Service set up a marine section which took over the Maui platform forecasts and became responsible for all storm warnings and coastal weather bulletins. This continued in the tradition of Capt. Edwin with his coastal storm warning system of 1874. The marine section has undertaken many special tasks and its services have been particularly sought by ocean-going yachtsmen. The operational forecasting of wave and swell conditions is now carried out using a computer programme developed specially for the purpose.

Medium and long range forecasting

The possibility of extending the weather forecast beyond the usual one or

two days has been extensively investigated by meteorologists around the world. The United States Weather Bureau began issuing thirty-day forecasts in 1948 based on a combination of current tendencies in the development of the weather systems, and statistical relations. This method predicted weather in terms of the deviation of temperature and rainfall from the monthly averages.

The British Meteorological Office produced similar forecasts based on the theory that a sequence of weather events will follow the same course if the initial conditions are the same. The problem was to find in the historical record a period when the conditions were as close as possible to the present. Other factors such as sea surface temperatures and snow cover, which may modify the outcome were then taken into account. Because of the difficulty of finding an exact analogue the rate of success of the forecasts was not high and in Britain the forecasts are no longer issued.

In New Zealand the limited data gave the application of such methods even less chance of success than they had in the Northern Hemisphere. However, there was continuing public interest in the possibility of longer range forecasting. Its value in a primary producing country is self evident and as recently as 1980 the NRAC asked the Service for a report on its possibility. It was told that there were no good grounds for assuming that useful long range forecasts could be made but the prospect for the medium range was much more hopeful.

The life of individual features on the weather map is about three to seven days and the methods of numerical weather forecasting are able to follow them if the initial information covers a large enough area. Data on this scale for a large part of the hemisphere are available under the WMO World Weather Watch. In Wellington detailed southern hemisphere information is received daily from both the World Meteorological Centre in Melbourne and from England.

In 1975 a consortium of European states set up the European Centre for Medium-Range Weather Forecasting (ECMWF) which was located in Reading, England from 1978. It receives all the available world-wide weather data on the Global Telecommunications System of the WMO, and with a sophisticated atmospheric model produces global weather maps and forecast charts. Forecast to five days ahead for both the Northern and Southern Hemispheres are distributed daily and received by a number of nations outside the European Community. The sections of interest to New Zealand are received in Wellington.

Because of the very large computing capacity at the European Centre the resolution in their atmospheric model is about 100 km compared with the

380 km spacing in the New Zealand calculations. Consequently European four-day and two-day forecasts for the New Zealand region are more skillful than the local computer forecasts for two- and one-day respectively. The European Centre three-day forecast shows similar skill to that displayed by the manually produced 24-hour forecast in the days before numerical weather prediction. With the aid of the daily information from the European Centre and from Melbourne, the Service began to issue four-day forecasts for New Zealand in February 1984.

Until these four-day forecasts, the only medium range predictions issued were special notifications of weather suitable for haymaking. Individual farmers could ask to be informed by telegram when several days fine weather was expected. The four-day forecasts now issued are possible only with the services of large international organisations outside New Zealand. The European forecast received in New Zealand for our local weather is often amended in Kelburn in the light of local knowledge and more recent observations. Changes may be made to surface and middle atmosphere forecasts and to large scale patterns before being interpreted in terms of New Zealand's weather.

The accuracy of numerical forecasts beyond the medium range soon drops off because errors grow as the calculations proceed. Longer range forecasting requires a different type of treatment and forecasts are only possible in broad terms. The problem of regularly achieving accuracy in these forecasts is yet to be solved.

The summer of 1982-83 was the only occasion when it has been found possible to issue long range forecasts with any prospect of success. This was due to atmospheric conditions over the Pacific and Indian Ocean tropics and sub-tropics being highly unusual. A 'southern oscillation index', which is an indication of the large scale exchange of air between the Indian and Pacific Oceans, was very low while the sea surface temperatures along the equator from South America to the Date Line were higher than normal.

Statistical studies between the southern oscillation index and anomalies in the wind flow, temperature and rainfall over New Zealand enabled the Service to issue a statement in December 1982 on the weather probabilities in January to March 1983. It predicted that westerly winds were likely to be stronger than usual, with wetter conditions over the West Coast and drier on the east coasts. Except for two weeks in February, the forecasts were remarkably accurate. A similar type of prediction issued in early March for the period March to May 1983 did not fare quite as well. When the southern oscillation index returned to a more normal value predictions were stopped, as relatively poor statistical relations had been found in such cases. It was

only the rare extreme value of the index which enabled a forecast to be issued with any degree of confidence.

Has forecasting accuracy improved?

The present day weather forecasters in the NWFC are deluged with information: conventional reports from both the surface and upper air; reports from aircraft and drifting buoys in the southern oceans; satellite cloud pictures; computer forecasts from England and the Service's own computer; and hemispheric weather charts from Australia. Whereas the meteorologists of forty years ago would spend time wringing the maximum information from each report on a data sparse weather map, their successors have to digest an almost overwhelming mass of data, a process which would be quite impossible without the processing and analysing power of a computer.

It is valid to ask whether this huge increase in available data and the technological aids which go with it have produced a corresponding increase in the accuracy of the product. It is undeniable that more weather forecasts for specialised purposes are produced now than ever before and that the demand for them continues to grow. Whether their accuracy has increased in proportion to the data input is difficult to answer precisely.

The forecast weather maps now available in New Zealand from the Service's own computer have shown only a slight improvement in accuracy over those which were manually produced in the immediate pre-computer days. There is little doubt that more computing power will allow the use of a more realistic atmospheric model and give further improvement. This has been shown by the success of the European Centre products. However the by-products of the present New Zealand calculations, such as the vertical motions of the atmosphere which determine the areas of cloud and rain, have been found very useful in forecasting the actual weather. The impact of the computer on the public weather forecasts cannot be quantified because of their qualitative nature. There appear to be no dramatic improvements. In the forecasting of winds and temperatures for aviation, where accuracy can be measured, the computer has made significant improvements. Its forecast winds are about 30 per cent more accurate than those manually produced.

The skill of the computer forecasts themselves, has only increased slightly over the last few years. Planned improvements in the computer model are expected to result in the 48-hour forecasts being at least as skillful as those currently available for 24 hours.

The computer has, however, completely changed the structure and operations of the Service by increasing the range of the services provided. New Zealand's role will never be to compete with European Weather Centre

forecasts. Within the framework of the global forecasts, the Service has the opportunity to focus on detailed, short and medium term predictions for the New Zealand region. Improvements in computer models, the greater use of weather surveillance radar, and an increase in the automatic weather station network give promise of a more detailed community weather service than that presently available. With current facilities the weather outlook has been extended to 4—5 days. Within that limit available technology can give greater forecast precision.

10
Research

The annual report of the Meteorological Service for the year ending 31 March 1948 saw meteorological research in New Zealand as a means of improving the weather forecasts, the main product of the Service. The chief aim of research was given as:

> . . . to carry out systematic practical and theoretical studies in the meteorology of New Zealand with the aim of improving the accuracy of current weather forecasts and extending the time range of their validity . . . In all cases great attention is paid to meteorological work done overseas with a view to possible applications to rather specialised conditions.

A substantial part of the Meteorological Service's research since 1948 had had as its object the improvement of the quality of the services provided. With the years, the extent of those services has become greater and although there has always necessarily been a lot of derivative work, original local input has not been lacking. Much of the research has been aimed at a better understanding of atmospheric processes in the South-West Pacific, which is often a prerequisite for the solution of a particular problem.

C. E. Palmer's extended range forecast project for the tropics was terminated in 1945, and attempts were then made to use empirical methods for extending the short range forecasts for New Zealand to 48 hours. Most methods tested were found to be of little value, and this project too, was discontinued. It was realised that progress would come only by accounting for weather phenomena by general dynamic and thermodynamic principles.

While this approach was correct and was to lead eventually to the computer modelling of atmospheric processes, the resources to do much about it were miniscule. J. W. Hutchings, appointed in 1948 as a Research Section of one, was the only meteorologist nominally full-time on research duties until J. F. Gabites returned from the United States in 1950, to take charge of research in the Service. Apart from the occasional temporary attachments, the full-time research staff did not exceed five for the next 15 years.

The annual meteorological conferences in Wellington provided an incentive for operational meteorologists to take on at least one investigation a year. These were mainly local studies of climate and weather, or empirical exercises

carried out in attempts to establish forecasting rules for New Zealand and the Pacific. Many were written up as internal reports.

There was enough upper wind and temperature data accumulated by the early 1950s to make a start in compiling upper air climatologies, and establishing the mean circulations at high levels over New Zealand and the sub-tropics. This led to Hutchings' discovery of the sharply concentrated core of winter westerly winds at an altitude of about 12 km in the sub-tropics to the north of New Zealand. These jet streams had striking differences from those found in the United States and their influence on the weather and dynamics of atmospheric circulation in the South-West Pacific was to be intensively studied. A succession of case studies of individual storms in the Australia-New Zealand area, designed to investigate physical mechanisms, appeared as technical reports and published papers from this time on.

The main interest of the new research section in physical meteorology, was the measurement of total ozone amount by the Dobson spectrophotometer and the resulting studies on ozone variability. The saga of this instrument is described later.

Besides these projects there was a continuing stream of *ad hoc* problems, and with the small number of meteorologists to deal with them the resources of the Service were spread very thin.

In the late 1950s and early 1960s every opportunity was taken of attempting to interest the university departments of mathematics and physics in atmospheric science. Students were employed in the research section during the summer vacations on supervised projects, in the attempt to encourage recruiting. The scheme was useful as a public relations exercise but did little to alleviate the immediate staffing problem. No guarantee could be given to even the most highly qualified student that on joining the Service he would be assigned to research duties.

The position was to change only very slowly, and while it had begun to improve before the integration of the computer into the operations of the Service, it was only afterwards that this factor and the improved training of technical officers permitted a greater proportion of staff to be diverted into research and development.

The opportunities for contact with meteorologists overseas during this period were small. The allocation of funds for travel was usually only just enough to secure attendance at the WMO and ICAO meetings, at which the Service had an obligation to be represented. Decisions made at these meetings usually affected the operational activities of the Service.

It was clear that the only way of raising the general scientific standard

of the Service was to attempt to build up a core of meteorologists who had been exposed to advanced academic and technical training. As this could not be done in New Zealand, it entailed overseas study and competing with other government departments for study awards. The first breakthrough was in 1963, when D. C. Thompson won an award to the Massachusetts Institute of Technology, where two senior members of the Service had been for their post-graduate training. Since that time, a succession of meteorologists have gained doctorates at universities in the United States, Canada, and Britain. The contacts made and the success of the New Zealand meteorologists in their studies have later brought many of them invitations for temporary attachments to overseas universities and research establishments.

In 1965 there was very little interest in atmospheric science in the New Zealand universities. The main projects were in the fields of:

- the electrical properties of the ionosphere — at Auckland and Canterbury.
- atmospheric electricity — Auckland.
- climatology — in the geography departments of Auckland, Canterbury, and Otago.

Victoria University of Wellington had plans at the time to establish an Institute of Geophysics and appoint a senior lecturer in meteorology who would be attached to the Department of Mathematics. J. W. Hutchings left the Service and took up this position in 1968; thereafter the introductory training course for meteorologists run by the Service has included the university lectures given in dynamical meteorology, the physics of the oceans and the atmosphere, and latterly also in physical meteorology.

From these beginnings the university interest in meteorology and climatology has increased, with six New Zealand Universities now having some teaching or research projects in atmospheric science. There is however still no university department of meteorology in the country. The Service has made use of the research contracts with university departments to encourage co-operation and to make use of their skills. The first contract was given in 1974 and there is now a close liaison with those university departments with interests in atmospheric science, and a number of co-operative research projects have been carried out.

Atmospheric dispersion studies

In the 1950s the Service began its association with the Health Department in what has become a major part of its applied research effort — the dispersion of pollutants in the atmosphere. The Health Act 1956, for the first time in New Zealand, required the licensing of industries and their supervision by chemical inspectors to control atmospheric pollution. From the beginning

the Meteorological Service, which has no regulatory powers itself, has advised the Health Department on the dispersion of pollutants and the pollution potential of the sites chosen for industrial plants.

This part of the Service's research and development programme is concerned with solving specific meteorological problems referred to it by outside organisations. It is not part of the provision of ongoing services. However techniques may be developed in anticipation of requests and used later for extending knowledge of atmospheric processes.

Both Auckland and Christchurch had major pollution problems in the 1950s and the Branch Offices there gave local advice. A small unit in the Research Section was set up with a roving commission for field surveys. Techniques of pollution estimation were at first very simple and leaned heavily on the use of climatological data, some site observations, and theoretical diffusion models. Over twenty-five years methods have become increasingly complex and refined.

The expected large increase in the electricity demand in New Zealand led to the planning of oil and coal fired power stations, and more latterly of geothermal stations. Nuclear power generation was at one time also considered, but later discarded. Prospective sites around the country were assessed by the government departments concerned with public works and electricity generation while the Service gave advice on the pollution potential of each site. In most, meteorological measurements were made on site. Atmospheric tracers were used to map the wind structure in the lower layers of the atmosphere, and the temperature structure determined to build up a turbulence climatology.

From the time of the 1966-67 field trials for the New Plymouth 500 MW power station, the Service has been involved in all power schemes and large industrial developments in New Zealand. It has carried out surveys from Ngawha in North Auckland, to the Bluff aluminium smelter site in Southland.

Besides assisting those agencies concerned with development, the Service has also co-operated with the Health Department and the Commission for the Environment which have regulatory and environmental assessment roles.

A whole battery of atmospheric probes and sensing techniques was been developed. Towers up to 100 m high have been erected at sites under investigation, and instrumented with wind and temperature probes: chemical methods have been used to measure the dispersion of a released tracer gas: acoustic radar, in which the reflection of sound waves from density inhomogeneities in the atmosphere is determined, has been used to find details of the turbulence structure in the lowest few hundred feet: computer models have been developed to calculate the dispersion over broken terrain.

Many projects have entailed working with overseas consultants and numbers of government departments. The Service is now recognised as having the expertise to give impartial advice on air pollution problems anywhere in New Zealand.

On a larger scale of dispersion in the atmosphere, the Meteorological Service was called on to estimate the trajectories and diffusion of the radioactive clouds from the British and French atmospheric nuclear tests; and contribute to a report to the Government on the likely contamination in New Zealand. The National Radiation Laboratory, Christchurch, monitored the radioactive deposits after the tests, and a number of meteorological stations in New Zealand and the Pacific acted as monitoring stations.

Growth of research effort

The National Research Advisory Council (NRAC), after an investigation of the Service in 1966, recommended that the research effort should be doubled in five years. At the time there were six meteorologists engaged on research duties. This was easy to recommend and also highly desirable, but impossible to achieve without a greater willingness on the part of the Government to give increased support to meteorology. It came only slowly, and not within the period recommended by the NRAC. By 1975, with the return from overseas of meteorologists who had been on study leave, the Research Section had grown to ten meteorologists and six technical officers. This modest increase was surpassed in the following ten years, when research numbers grew by a factor of three.

The most striking of the changes in the organisational structure of the Meteorological Service in the last ten years has been the growth in its research component. This has come about partly by increases in the total numbers of the Service, but mainly by the internal re-allocation of duties made possible by technology. The computerisation of the Service has enabled weather forecasting to be centralised and, with the upgrading of technical officer training and duties, allowed a greater proportion of staff numbers to be directed to research work. The total staff of the Meteorological Service was 347 in April 1983, and the number engaged principally on full-time research and development was 46. This comprised 30 meteorologists, 14 technical officers, and 2 computing staff. It excluded those engaged in training duties. In addition, a further 7 meteorologists, 5 technical staff, and 5 computing staff, were engaged for more than a quarter of their time on research and development. Considering the size of the organisation and its range of responsibilities, this is satisfactory except in the proportion of technical officers to meteorologists which is far too low.

The improved recruiting prospects for meteorologists have enabled the Service to bring in a planned mix of physicists, chemists, instrument specialists, mathematicians, statisticians, and computer experts, to cover most of the broad fields in which the Service is expected to provide expertise. No longer is it necessary for one meteorologist to deal with a whole variety of topics. Specialisation is possible, and the feedback between the specialists in a wide range of disciplines has produced an increase in the quality and quantity of the work produced. A rise in professional staff recruited with higher degrees, together with those sponsored for overseas study, has brought the number with doctorates to about 20 per cent of meteorologists. The New Zealand Meteorological Service is well regarded internationally for the standard and breadth of its scientific activities.

Visits to the Service by overseas meteorologists and from scientists from New Zealand universities have increased, and temporary attachments by visiting scientists are an established procedure. The funds allocated to the Service for overseas travel remain small and there is still the obligation for New Zealand to be represented at meetings of the international organisations. However greater numbers of research meteorologists are visiting overseas institutions than ever before, often being funded from sources outside Government.

Some indication of the worth of research effort can be judged by the papers published in the scientific literature, and the reports put out by the Service. About forty substantial publications and reports appear each year. The recent establishment of a Scientific Information Services Section has brought a greater professionalism into the production of the scientific reports, and in the publicity and educational material produced.

Research and development areas

Because of the recent growth in research in the Service it has been found possible to set up small groups to cover each of the main research and development areas of interest. In its contribution to a 1983 NRAC discussion paper 'A review of science and technology in New Zealand' the Service identified eight programmes:

- weather prediction research
- climate studies
- air pollution meteorology
- data acquisition systems
- data services
- agricultural meteorology
- atmospheric physics and chemistry
- Antarctic meteorology.

Weather prediction

In order to produce more accurate, more detailed, and longer range weather

predictions, there has to be a further development of dynamical, statistical and observational techniques. The large meteorological centres have the staff and computer resources to produce global analyses and forecasts of the large scale motions of the atmosphere to five days ahead. New Zealand takes advantage of this work, and is critically dependent on the global data acquisition and communications systems co-ordinated by the WMO for its reception.

Within the broad global framework, the Service is working to develop more accurate and detailed numerical weather analysis and prediction models. These will require advanced methods of using satellite data, and aim to give improved 48-hour forecasts. The upgrading of the Meteorological Service computer will permit the operational use of these methods. The present model gives operational forecasts of the large-scale atmospheric flow patterns for up to 48 hours ahead, over one-third of the Southern Hemisphere. Local weather elements (maximum and minimum temperatures, rainfall probabilities, and surface winds) are derived statistically from the computer output. An operational model which predicts the state of the sea has also been produced. These products will be improved with enhanced computing facilities.

Work is continuing on developing techniques for very detailed forecasting for short periods ahead. Difficulties in achieving this are introduced by New Zealand's broken topography. Methods of using high resolution satellite data together with weather surveillance radar are planned.

Climate studies

Studies of climate in the Service have traditionally been a mix of descriptive accounts of regional climates, and statistical and mathematical investigations into models for the interpretation of climatological data and the dynamics of climate.

Accounts of the regional climates of New Zealand are almost complete and the more populated of the Pacific Islands are being similarly treated. Statistical methods have been developed for estimating solar radiation from sunshine observations, frost likelihood, and for characterising rainfall occurrences and their extremes. The many recording anemometers around the country have provided information for investigations of the structure of the surface wind, needed for the calculation of wind effects of buildings and for wind energy studies.

Analysis of the upper air circulation characteristics of the Southern Hemisphere is a continuing project, which seeks to establish relations which may lead to longer term weather predictions. The variations on different time

scales of surface temperature and rainfall, and of atmospheric circulation indices, have been investigated for climatic variability.

The experience of many meteorologists in Fiji, and the close association with the new Fiji Meteorological Service, have given an incentive for both synoptic and climatic investigations into tropical circulations. Since the studies by Hutchings in 1953 there has been an interest in tropical cyclone occurrences, and a number of climatologies and research papers have been produced.

Data acquisition systems

The Service has to take advantage of the modern developments in the technology of data gathering if it is to improve its weather forecasting and meteorological advice capabilities. The small instrument section set up in the latter stages of the War was mainly occupied with providing instruments for the surface and upper air observations. There was a machine shop, for many years with only one technician, and much of the mechanical servicing was done commercially.

The assessment of new radars for wind finding and weather surveillance, and of radiosonde equipment, was done in association with the Civil Aviation Divison. The Service had no electronics laboratory, and was not able to expand in this field until 1968 when the design of a prototype automatic weather station was started.

The electronic maintenance and development was separated from the mechanical workshop and the latter moved to Paraparaumu in August 1979, as the initial stage in the establishment of a meteorological centre. It provides facilities for instrument calibration, maintenance and research, and for the field testing of operational instruments; it will ultimately act also as a field station for agricultural meteorology.

The instrument development section designed a data recorder for logging meteorological variables on magnetic tape at remote sites, and a number have been used for environmental surveys. The section was closely involved in the installation of the new satellite receiving equipment, and its specialists in remote sensing continue to explore the possibilities of the satellite observations for improved derivations of atmospheric and surface data.

The retrieval of vertical temperature profiles from the satellite transmissions has given valuable additional data for numerical weather prediction. Sea surface temperature charts are produced each week from infra-red measurements made by the polar orbiting satellites. Methods have been developed to correct the calculations for the absorption by cloud and water vapour of the radiation from the sea surface. The derived temperatures are

thought to be accurate within about one degree Celsius, and a composite sea surface temperature chart for the waters around New Zealand is supplied routinely to the fishing industry.

Besides its own development work in data acquisition, the Meteorological Service has supported international programmes designed to fill the gaps in the conventional reporting networks. The Southern Hemisphere drifting buoy project of 1978-79 was part of a global experiment. About 300 drifting buoys which measured pressure, sea surface temperature, and position, and reported by satellite, were deployed at intervals in the southern oceans by eight nations. The buoys had a life of about a year. New Zealand provided ten, and the data when tested by the Meteorological Service were found to have a beneficial effect on numerical weather map analyses and forecasts in the Australia-New Zealand area. They gave a most valuable additional source of sea surface temperature measurement. The drifting buoy project is to be an ongoing international programme which New Zealand will continue to support.

The Service is also part of a consortium to develop equipment to relay in-flight meteorological data from wide-bodied jet aircraft via satellite. The information, which is automatically recorded every seven minutes, will be transmitted every hour and distributed over the Global Telecommunications System of the WMO. The first production units of the equipment are expected to be in service by 1986. The Aircraft Satellite Data Acquisition and Relay (ASDAR) system will be an important contribution to global weather analysis and forecasting.

The longest standing of the joint data gathering projects with which the Service has been associated, was the Global Horizontal Sounding Technique (GHOST) project which operated from Christchurch from 1966 to 1985. Super-pressure balloons of thin mylar were designed to drift around the Southern Hemisphere at a constant pressure level, reporting their position daily. They were tracked from a number of stations, of which Christchurch was one, around the Hemisphere and gave information on the large scale motions in the upper troposphere and lower stratosphere.

The GHOST project was under the supervision of V. J. Lalley of the National Centre for Atmospheric Research, Boulder, Colorado, and was subject to a joint United States-New Zealand agreement. New Zealand's part was to provide the staff for the tracking duties. The balloon technology was highly ingenious, and some individual balloons were tracked for well over a year. The project was mothballed in 1985.

Over the last ten years new technology has provided the meteorologist with an ever increasing range of atmospheric information. It is expected that the

growth trend in the volume of data from automated and remote sensing devices will accelerate.

Data services

The Service holds a computerised archive of much of the New Zealand and Pacific Islands meteorological data. Current data are recorded on magnetic tape, and historical written records are being gradually transferred to the computer files. It is part of the statutory duty of the Service to hold the national archive of weather information, and to make raw data, summaries, and analyses, available to the public. This is essentially a service activity.

However, there is a development component in deriving characteristics of climate for specialised requirements. Statistical techniques for sampling, condensing, and analysing, the voluminous data from remote sensing devices are being developed. The raw data needs of agriculture, industry, and commercial organisations are growing, and experience is being gained within the Service with the statistical analysis of large data sets.

Air pollution meteorology

Techniques for assessing the atmospheric impacts of emissions from proposed industrial projects, and from urban communities, have been well developed. While there are a number of other agencies, government departments, local bodies, consulting engineers, and universities, working in the field, the Service has accumulated comprehensive expertise and can give up-to-date advice on the meteorological aspects of air pollution.

The work on modelling air flow and dispersion is a continuing project. Wind and temperature information from automated instruments, advanced numerical models of atmospheric flow in broken terrain with consequent complex dispersion patterns, together with experiments using tracer gas give promise of greater precision in dispersion predictions.

Agricultural meteorology

In 1932 Kidson, writing to Professor G. F. Peren, principal of Massey Agricultural College, said:

> But I feel very strongly that climatic factors are by far the most important amongst those controlling the output from our primary industries and thorough study and appreciation of them must lead to important results. Yet in New Zealand there is no one engaged in agricultural problems who is making a serious effort to correlate climatic and other factors. Indeed, I am sure that none have the special knowledge to enable them to do so.

Kidson himself, amongst his other numerous activities, made a start in

providing climatic data, research reports and correlation studies for the use of agriculturalists. After the war, although the Service had close contact with the Department of Agriculture through its climatological section, there was no one meteorologist assigned to agricultural meteorology. Investigations on evaporation and soil moisture, growing degree-days solar radiation, and meteorological factors involved in facial eczema were carried out.

In 1963 J. D. Coulter was appointed as the first agricultural meteorologist, and a more sustained effort was put into finding what the Service should be doing to assist primary industry, as DSIR, MAF, and Ministry of Works and Development were all engaged in research with a bearing on agricultural activities. In order to avoid duplication of effort, the agricultural meteorologist had a close liaison with the other agencies and successive holders of the position have expanded the scope of the Service's contribution.

The Service has been able to venture into primary production forecasting, and provides weather information to economic planners. With primary products making up almost 50 per cent of New Zealand's export receipts, production volumes have an important bearing on the balance of payments and must be monitored. The transport, processing and marketing sectors require accurate advance assessment of the amount of primary production.

In 1934 the Bank of New South Wales asked the Meteorological Division of DSIR for information on the economic value of the weather on farm produce — specifically on sheep, cattle, cropping, and fruit production. No answer could be given at the time. Forty years later W. J. Maunder began a collaborative project with the New Zealand Dairy Board, which led to the development of empirical relations giving predictions of dairy products for up to three months ahead. This was followed by similar work for the Meat and Wool Board. Other economic activities have been treated in a like manner, by deriving climatic indices appropriate to each activity. The weather sensitive sectors of New Zealand's economy have been identified and (virtually) real-time climatic information is now available for each activity.

Atmospheric physics and chemistry

Although aspects of atmospheric physics have been under study in the Service for many years, it is only with the increase in allocated resources that the subject could be treated in a more systematic and comprehensive manner. The object of the atmospheric physics group is to 'monitor and study the composition, microphysics, and energetics of the atmosphere, with special emphasis on atmospheric chemistry, cloud physics, and solar and terrestrial radiation'. The part that these processes play in global pollution, climate, and climatic change, is assessed.

Monitoring the changes in the atmospheric constituents implies a long term commitment, and careful standardised monitoring techniques. Some of the programmes contribute to the WMO research plans and form part of the global data base. There are programmes currently underway in atmospheric ozone and turbidity, and solar radiation and cloud physics. Some of these are a continuation of long established projects.

Atmospheric ozone

Attempts were made to measure ozone amounts at the surface in the mid-1870s at Auckland and Christchurch. No details are available but it appears that chemically impregnated papers were exposed to the air and a 'Schonbein's ozone scale' was used to give ozone amounts. In 1877 Hector had the observations discontinued as the results from the stations were found to give little variation.

Dr C. M. B. Dobson of Oxford organised the first global survey of atmospheric ozone, and New Zealand took part with Professor C. Farr of Canterbury University College making observations with a borrowed Fery quartz spectrograph during August 1928 to November 1929. Kidson attempted to find the relations between the total ozone amounts found above Christchurch and the weather at the time.

In 1937 the DSIR purchased one of Dobson's 'new' photoelectric spectrophotometers, which was to be operated by the Meteorological Office at Wellington. The instrument was not ready for shipping from Britain until the outbreak of War, and the Dominion Office in London asked permission to retain it in England for the duration of the hostilities. It was required for 'urgent defence investigations' since there was a belief at the time that the daily changes in ozone amounts were related to variations in the weather systems and thus of use in weather forecasting.

The instrument did not arrive in Wellington until 1950, and was sent to the Dominion Physical Laboratory of the DSIR before being transferred to the newly formed research section of the Meteorological Service in 1951. Observations under the supervision of Edith Farkas were made on a five-day week basis, until the spectrophotometer was shifted to Invercargill in 1970.

Since then the New Zealand Dobson instrument has been part of the world ozone network, and is a much modified and well travelled instrument. It has been twice to Australia for calibration and modification, and once to Toronto for recalibration after comparison with the North American standard. It suffered serious damage when the Invercargill station was flooded in 1984, and had to be sent to the Central Ozone Laboratory at Boulder, Colorado, to be completely stripped and repaired.

Besides the routine monitoring of total ozone amounts, the Service has also made measurements of surface ozone concentrations and of the vertical distribution of ozone. During the International 'Quiet Sun Year' of 1964-65, soundings of the ozone distribution were made at Christchurch with the Brewer Ozonesonde. In 1970 a number of ozonesonde ascents were also made at Invercargill. Surface ozone has been continuously measured at both Scott Base and Invercargill.

In an attempt to obtain a reliable instrument for the measurement of total ozone, which would be more compact and cheaper than the Dobson Spectrophotometer, the Service made a research grant to the Physics Department of Canterbury University. A prototype of a narrow band filter spectrophotometer was produced, and an improved version made available to the Service in 1974 for comparison with the Dobson instrument at Invercargill. It proved successful and several were produced commercially.

Atmospheric turbidity

The increasing concern about global atmospheric pollution and its possible effects on climate, has let to a world wide network of stations monitoring the turbidity of the atmosphere. Since 1980 the Service has made regular measurements at Rarotonga as well as in New Zealand, and more recently at Scott base.

Solar radiation

For many years there have been measurements made in New Zealand of the total solar radiation received on a horizontal plane at the earth's surface. A series of observations were taken at Wellington in 1932-35 using an Angstrom Pyrheliometer but these were not continued. The monitoring of daily sunshine amount started much earlier, and today there are about ninety stations measuring sunshine hours.

After the War discussions with the DSIR resulted in the Meteorological Service accepting responsibility for monitoring solar radiation in New Zealand. In 1953, Eppley pyrheliometers and recorders were installed at Whenuapai, Wellington, Ohakea, and Invercargill. The network has now grown to eight stations in New Zealand, two in the Pacific and one in the Antarctic. The radiation network was also supplemented by a number of simpler, less accurate bimetallic recorders. Since 1975 the Eppley precision pyranometers have been replaced by an improved model, and total solar radiation is now monitored by instruments calibrated according to the 1980 World Reference Scale. The Service has set up a calibration facility. The replacement of the old bimetallic recorders by more modern sensors began in 1983.

Cloud physics

Until 1978 there was no research programme in cloud physics. During droughts the Service was consulted many times by farmers' organisations and by the Government on the possibility of alleviation by cloud seeding. The advice given was based on literature surveys, analyses of New Zealand cloud observations, and a close association with the Cloud Physics Section of the Commonwealth Scientific and Research Organisation, Sydney. In 1969, against the advice of the Service, the Government authorised cloud seeding by the RNZAF in South Canterbury and North Otago.

With the appointment of a cloud physicist a programme of basic measurements of cloud water droplets began in 1979, and in 1981 the Service purchased a sailplane for cloud physics research. It has been instrumented to sample water drops in cloud, and investigate the dynamics of flow in and around cloud.

An F-27 Fokker Friendship aircraft of the Ministry of Transport Calibration Flight has provided another platform for carrying cloud physics measuring probes. Instrumentation began in 1982 and it is to be used for sampling of atmospheric particles and trace gases as well as for cloud physics investigations.

Atmospheric chemistry

There is now increased recognition worldwide that trace atmospheric constituents have important effects on the transfer of solar radiation through the atmosphere and hence on climate. The Service has interests in monitoring a range of substances in addition to its studies on ozone and atmospheric turbidity, and the development of an airborn monitoring facility.

With the co-operation of the Hamilton Science Centre it has initiated routine monitoring of New Zealand rainwater for various chemical radicals. Carbon dioxide, the most radiatively important gas, is monitored in New Zealand by the Nuclear Sciences Division of DSIR with assistance from the Meteorological Service. Recently, carbon monoxide and certain halomethanes and hydrocarbons have been recognised as having considerable significance in radiative transfer. Facilities for monitoring some of these substances are being developed in the Research Section.

Antarctic meteorology

The Meteorological Service's Antarctic programme has had as its principal aim since the IGY, collection of high quality data series from Scott Base and Lake Vanda. The monitoring of ozone and of solar radiation has been carried out in addition to the usual synoptic and micrometeorological observations.

Pilot studies in atmospheric chemistry and air composition were initiated in parallel with similar work in New Zealand.

The data collected have been used in studies of the local climate and the heat balance in the Ross Dependency. There is a challenge in understanding the role of the Antarctic continent on global weather and climate, and more especially, on the New Zealand region.

Epilogue

We have traced in these pages the 125 years of government funded meteorology in New Zealand. For the first half of its existence the Meteorological Service was a small, struggling, organisation suffering long periods of minimal support. There was no significant growth in numbers until after Dr Kidson was appointed in 1927. He came to a staff of 4, which had increased to 58 by 1940 and today is about 350.

Over the last forty-five years New Zealand has been obliged to accept meteorological responsibilities over much of the South-West Pacific. During this time the staff of the Service have served from the equator to the South Pole. While resources were usually spread very thinly, its record is one of which it has the right to be proud.

The Service has suffered more than its fair share of organisational changes. Weather and climate impinge on so many diverse activities of the community, that the public demands on a meteorological service change with social conditions. This has caused difficulty for the politicians and administrators in finding a niche for the Service within the State Service structure. There have had to be compromises, and on occasion the controlling department was an unwilling host to the Service. At other times there has been a tendency for the controlling authority to consider that its own sectional interest should be the main concern of the Meteorological Service.

A chance for an escape from this attitude came with a review of New Zealand science in 1926 by Sir Frank Heath, prior to the establishment of the DSIR. He recommended that a meteorological service should serve all users alike, and would do best if attached to none of them, but was subject to the 'criticism and inspiration of competent scientific judgement.' So the Meteorological Service became, for a short time, part of the DSIR.

Heath's view was a restatement of the sentiments expressed by the 1925 report of the Board of Science and Art. As Sir Ernest Marsden was a member of the committee, and was also closely associated with Sir Frank Heath, this is probably no coincidence. The Board's solution to the problem of the control of a meteorological service by non-technical adminstrators of a host department, was to interpose an advisory board of control. The host department would have a purely administrative function, while policy would be approved by the government appointed board of control.

Sixty years later the same questions about the most appropriate administrative control for the Service are again being raised, and the solution proposed earlier looked at in the light of changed circumstances. The Meteorological Service of 1985 is a different type of organisation from that of 1925, but the principles involved in finding a location within the State Services to give sympathetic administrative control remain the same.

The growth of civil aviation in the Pacific region and the requirement of meteorological services by the RNZAF during the war brought a preoccupation with a major sectional interest. Meteorology in New Zealand gained enormously from its close association with aviation, which still continues today to be an important client. However the needs of aviation today are quite different from those forty years ago. Changes in aviation have posed new problems for meteorology which advances in computers, telecommunication technology, and in meteorological science have been able to meet.

Meanwhile, new client groups have arisen and it is right that the arrangements for the weather services in New Zealand should be critically re-examined.

World-wide, the resources applied to the atmospheric sciences, whether in the state weather services or in the universities, are greater than they have ever been. International co-operation has resulted in a global weather reporting system, whose data are made available within a few hours of observation time via a sophisticated communications network. The global atmosphere is continuously monitored by meteorological satellites. World meteorological centres equipped with the latest computers, analyse the large-scale motions of the atmosphere and forecast their future development. The pace of technological advance in the development of meteorological sensors and automatic recording of atmospheric data shows no sign of slackening.

A small meteorological service has to adjust to these changes. It cannot duplicate the work of the large centres but within the framework of the hemispheric or global information received daily, it has the opportunity to devote itself to a more detailed study of weather and climate on a regional scale. In New Zealand there is an increasing demand for such information for agricultural, engineering, economic, marine and other transport, needs. The scientific and technical problems in providing these services are of considerable complexity.

The Service has changed in character over the last ten years. The application of new technology has enabled it to reallocate resources so that while there are more routine weather forecasting and climatological services than ever before, they can be provided by fewer staff. Much greater effort is then available for research studies on New Zealand's weather and climate and for

discovering new ways of meeting the meteorological needs of the community. There is every possibility that an application of advances in the understanding of atmospheric processes and changing technology will, in the future, bring further changes to the Service.

However, the political and economic mood of the times does not give an automatic guarantee that the State will fund the Service to enable it to take advantage of the expected meteorological advances. There is a stricter accountability in science now than was formerly evident. If the Meteorological Service is to receive from the public purse what it considers to be adequate funding, it must justify its activities, not only on scientific and technical grounds, but also on economic grounds. With the spread of the 'user pays' principle, the Service is now required by government to charge for some of its products and a return of 35—40 per cent of its annual expenditure from other than state funding is aimed at.

The Service has shown that it is well placed to meet the challenges: It is a flexible organisation — its scientific reports and papers, its instrument development and application of new technology, and its public services, show that it has the necessary professionalism and can adapt to change. There is a higher standard of scientific and technical training and a wider range of expertise than ever before. There are of course some shortcomings in the organisation and in services provided. However the Service has the potential to continue to make an effective contribution to meteorological science, and provide for the meteorological requirements of New Zealand.

The present organisation is heir to 125 years of endeavour by hundreds of people. If it had not been for the determination and vision shown during the lean years, when the supply of resources was minimal, the Service would not be today in the favourable position in which it finds itself.

The fascination of meteorological science has been experienced by large numbers of those who have worked for the Service. The atmosphere produces endless surprises and delights, and the rapid growth in our knowledge of the physics, chemistry and dynamics of atmospheric processes shows no signs of exhausting its secrets. The enthusiasm that this engenders was there in the past, and is present today. If New Zealand meteorologists are given the facilities which will enable them to retain their enthusiasm and continue to find satisfaction in their work, the future of the New Zealand Meteorological Service in a changing world is assured.

APPENDIX I

Directors
New Zealand Meteorological Service

1861–1867	Charles Knight, F.R.C.S.
1867–1903	Sir James Hector, K.C.M.G., M.D., F.R.S.
1903–1906	Augustus Hamilton
1874–1881*	R. A. Edwin, Commander R.N. (Retd)
1890–1906*	R. A. Edwin, Commander R.N. (Retd)
1906–1908†	R. A. Edwin, Commander R.N. (Retd)
1908–1927	D. C. Bates
1927–1939	E. Kidson, O.B.E., M.A., D.Sc., F.Inst.P., F.R.S.N.Z.
1939–1962	M. A. F. Barnett, O.B.E., M.Sc., Ph.D., F.Inst.P., F.R.S.N.Z.
1962–1965	R. G. Simmers, M.Sc., Sc.D.
1965–1973	J. F. Gabites, M.Sc., Sc.D., F.R.S.N.Z.
1973–1977	J. F. de Lisle, M.Sc., D.I.C., Ph.D.
1977–	J. S. Hickman, B.Sc.

* Captain Edwin was in charge of the Weather Reporting and Storm Signalling Department, which was separate from the Meteorological Department during this period.

† The climatological and weather forecasting organisations were permanently combined under Captain Edwin in 1906.

APPENDIX II

Observations of climate 1840–1860

In the tables below, details are given of the meteorological observations made in New Zealand during the period 1840–60. The dates given do not necessarily relate to complete years. The name of the observer, institution, or person in charge of the observational programme is given where known. The publications containing the observations or summaries quoted, or discussed, are also listed.

AUCKLAND

1840–41 David Rough, Harbourmaster.[1]
1840–44 Dr John Johnson, Colonial Surgeon.[2,3,4]
1849–51 Dr A. S. Thomson, Surgeon 58th Foot.[5]
1853–60 Lt. Col. R. E. Mould.[6]

[1]Dieffenbach, E., *Travels in New Zealand*, 1843, p. 285.
[2]ibid, p. 286.
[3]Swainson, W., *Auckland, the Capital of New Zealand*, 1853, p. 59.
[4]Terry, Charles, *New Zealand*, 1842, pp. 65–66.
[5]Swainson, W., op. cit., p. 60.
[6]*Statistics of New Zealand*, 1856–61.

NEW PLYMOUTH

1841 Weekes, Colonial Surgeon.[1]
1842 W. & H. Halse.[2]
1846–48 C. Hursthouse.[3]
1853–56 E. L. Humphries.[4]
1860–61 E. L. Humphries.[5]

[1]*Latest Information from New Plymouth*, 1842, pp. 32–33.
[2]*Letters from Settlers*, 1843, pp. 41–43.
[3]Hursthouse, C., *An Account of the Settlement of New Plymouth*, 1849, p. 6.
[4]*Statistics of New Zealand*, 1856.
[5]*Statistics of New Zealand*, 1860.

WELLINGTON

1840–42 New Zealand Company.[1,2,3,4]
1845–47 Mr Justice Chapman.[5,6]
1848–49 Dr R. K. Prendergast, Principal Medical Officer, 65th Foot.[7]
1848–50 Charles Sharp, Harbourmaster.[8]
1853–54 Dr R. K. Prendergast.[9]

[1]*New Zealand Gazette* (later the *New Zealand Gazette* and *Wellington Spectator*) from 25 April 1840.
[2]Petre, H. W., *An Account of the Settlements of the New Zealand Company*, 1841, p. 82.
[3]Dieffenbach, E., *Travels in New Zealand*, 1843, pp. 172–184.
[4]Terry, Charles, *New Zealand*, 1842, p. 67.
[5]Grimstsone, S. E., *Southern Settlements of New Zealand*, 1847.
[6]Earp, G. B., *Handbook for Intending Emigrants*, 1849.
[7]*Statistics of New Zealand*, 1856.
[8]*New Zealand Government Gazette* (Province of New Munster), beginning Vol.1., No.14.
[9]*Statistics of New Zealand*, 1856.

NELSON

1845–47 J. Barnicoat.[1]
1844–54 Samuel Stephens.[2,3,4]

[1]Earp, G. B., *Handbook for Intending Emigrants*, 1849, pp. 68–69.
[2]Drury, Capt. B., On the Meteorology of New Zealand, *New Zealand Gazette*, 1857, pp. 178–186.
[3]Earp, G. B., op. cit., p. 67.
[4]*Statistics of New Zealand*, 1856.

CHRISTCHURCH

1849–58 C. O. Torlesse.[1]
1852–55 Cass, Princ. Govt. Surveyor.[2,3]
1858 T. I. Cookson.[4]

[1]*Statistics of New Zealand*, 1858, 1859.
[2]Paul, R. B., *Letters from Canterbury, New Zealand*, 1857, p. 6.
[3]Drury, Capt. B., On the Meteorology of New Zealand, *New Zealand Gazette*, 1857, pp. 178–186.
[4]*Statistics of New Zealand*, 1858, 1859, 1860.

OTAGO

1848 N.Z. Company.[1]
1849–59 Revd Dr T. Burns.[2]
1849 John Anderson.[3]
1852–60 Revd Dr T. Burns.[4]

[1]*The Otago Journal*, 1849, p. 63.
[2]ibid, pp. 100–106.
[3]ibid, pp. 106–107.
[4]*Statistics of New Zealand*, 1856, 1857, 1858, 1860.

SOUTHLAND

1858 — (Rainfall at Bluff).[1]
1859 Charles Rous Marten.[2]
1860–61 Hon. J. R. Menzies.[3]

[1]*Statistics of New Zealand*, 1858.
[2]Hector, J., Colonial Museum and Geological Survey Department, Meteorological Reports 1868.
[3]*Statistics of New Zealand*, 1861.

KAIKOHE

1849–50 Revd R. Davis.[1]

[1]*Statistics of New Zealand*, 1856.

APPENDIX III

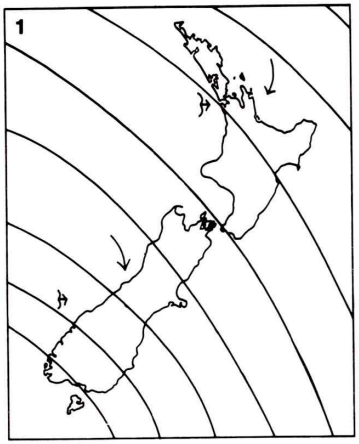
Weather diagrams 1882

In order to provide daily weather reports to the press, and to exchange weather information with Australia as cheaply as possible, the Meteorological Office prepared a series of typical isobaric diagrams based on about three years experience of analysing daily weather maps. Stereotyped copies of the diagrams were supplied to the leading newspapers in New Zealand in 1882, and a similar scheme was initiated in Australia. There were 24 diagrams for for New Zealand and 20 for southern Australia.

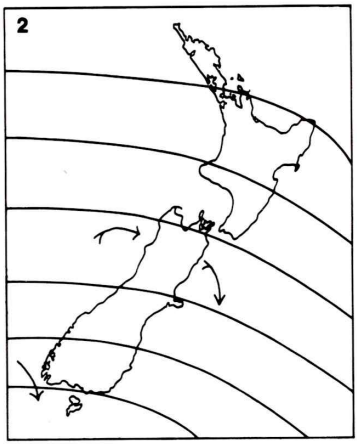
On receiving the diagram number for the day the journal printed the appropriate diagram, which was described by Hector as 'although not absolutely correct, is of great assistance in helping the public to a proper comprehension of the weather for the day at much less expense than by the publication of a specially prepared map or diagram.'

A descriptive note supplied to the newspapers, to be published with the diagram each day, pointed out that the dotted lines, or isobars, were based on pressure readings at 9 a.m., and that no account was taken of local deflections of the isobars due to the shape of the land. Arrows indicated the usual directions of the local winds. Changes of weather arose from the eastward progress of cyclonic or anticyclonic areas at a rate of 300–500 miles a day.

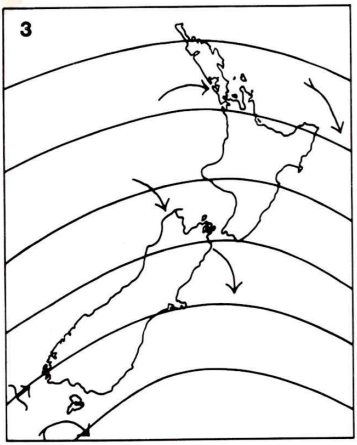
The Meteorological Reports of the Colonial Museum and Geological Survey for New Zealand for 1885 gives a description of the diagrams for both Australia and New Zealand. A selection of the New Zealand diagrams with accompanying notes is given here, for numbers 1 to 4.



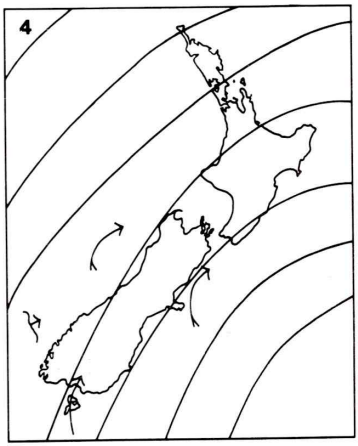
In No. 1 the centre is about 800 miles to the WSW of New Zealand. A cloud-bank looms up off shore on the West Coast, and a heavy swell rolls in from the westward.



No. 2, NW or westerly winds with rain on the West Coast, fine weather with lofty cirrus-clouds on the East Coast, and strong NW winds in Foveaux and Cook Straits and round the North and East Capes.



No. 3, SW winds and clearing on on the west coast of the South Island; NW rain in the north and dry NW winds on the east coast of the South Island, succeeded by a 'southerly bu'ster' with rain or snow according to season.



No. 4, southerly winds all over, and sky clearning. The change from NW to SW winds is frequently marked by the thunder-storms, especially on the west coast of both Islands.

APPENDIX IV

Extract from Civil Aviation Act 1964

PART IV

THE METEOROLOGICAL SERVICE

20. Meteorological Service—(1) There shall be a branch of the Department to be called the New Zealand Meteorological Service.

(2) There shall from time to time be appointed under the State Services Act 1962 an officer of the Department to be called the Director of Meteorological Services who shall be responsible for the administration of the Meteorological Service and who shall have such duties and functions as may be imposed or conferred on him by regulations under this Act or by the Minister.

(3) The Director of Meteorological Services shall be under the general direction of the Secretary but nothing in this subsection shall derogate from any of the powers, duties, and discretions conferred or imposed on him by regulations under this Act or by the Minister.

21. Functions of Meteorological Service—(1) The principal functions of the Meteorological Service shall be —

(a) To provide a meteorological service for the benefit of all sections of the community:

(b) To promote the advancement of the science of meteorology:

(c) To advise the Minister and Government Departments on all matters relating to meteorology:

(2) In the exercise of its functions the Meteorological Service shall generally do what is considered necessary for the efficient operation of a meteorological service and, in particular, it may, from time to time, —

(a) Arrange the making and recording of meteorological observations:

(b) Promote standardisation in the making of meteorological observations:

(c) Collect and preserve meteorological records:

(d) Compile meteorological statistics:

(e) Conduct meteorological research and investigation:

(f) Furnish advice on meteorological matters:

(g) Publish meteorological information and the results of research and investigation:

(h) Make and issue forecasts of the weather and other meteorological conditions:

(i) Supply meteorological information to Government Departments, persons engaged in civil aviation, and all other bodies or persons needing any such information:

(j) Co-operate with the authority administering the meteorological service of any other country or with any appropriate international organisation in relation to meteorological matters:

(k) Exercise such functions and duties as may be conferred on it by any enactment or as the Minister may from time to time direct.

(3) Charges of such amounts and in such circumstances as may be approved in that behalf by the Minister or as may be prescribed by regulations under this Act may be made in respect of any information supplied or services provided by the Meteorological Service.

APPENDIX V

Selected list of sources consulted

UNPUBLISHED PAPERS

There are large gaps in the surviving primary sources of information on New Zealand meteorology. Losses of papers occurred in, the wreck of the *White Swan*, 1862; the Wellington Post Office fire, 1887; the Hope Gibbons Building fire, 1952; and the fire at the Meteorological Service store, Aotea Quay, Wellington, 1961. The surviving files and papers are held in:

New Zealand Meteorological Service
The Alexander Turnbull Library
The National Archives of New Zealand
The National Museum of New Zealand.

UNPUBLISHED THESES AND REPORTS

Owen, J. B., *A Brief Survey of Meteorological Development in New Zealand,* Unpublished University of New Zealand thesis, 1946.

—— *War History Narrative of the Meteorological Branch RNZAF, 1939–45,* Unpublished typescript, New Zealand Meteorological Service.

Aeradio Committee Report, on Proposed Establishment of Radio and Meteorological Station on Raoul Island, Kermadec Group, 1938.

PUBLISHED OFFICIAL PAPERS

Annual Reports of the Colonial Museum and Laboratory

Annual Reports of Air Department, Civil Aviation Department, Department of Scientific and Industrial Research, Marine Department, and the Ministry of Transport

Appendices to the Journals of the House of Representatives.
Colonial Museum and Geological Survey Department
Meteorological Reports

Journals of the House of Representatives of New Zealand

New Zealand Government Gazette

New Zealand Government Gazette — Province of New Munster

New Zealand Government Gazette — Province of New Ulster

New Zealand Parliamentary Debates

Statistics of New Zealand
Wellington Provincial Council Votes and Proceedings

NEW ZEALAND METEOROLOGICAL SERVICE INTERNAL REPORTS AND PUBLICATIONS

Information Publications
Manual of Instructions
Miscellaneous Publications
Quarterly Review (started in 1948 as a newsletter and has appeared regularly since. An invaluable journal of Meteorological Service news and happenings)
Research Reports
Scientific Reports
Technical Notes

OTHER REPORTS AND PUBLICATIONS

The Islander — Quarterly Bulletin of the Campbell-Raoul Island Association, 1971–79.
World Meteorological Organization Reports

BOOKS

Atkinson, J. D., *DSIR's First Fifty Years*, Wellington, 1976.
Bailey, Alfred M. and J. H. Sorenson, *Subantarctic Campbell Island*, Denver, 1962.
Bayly, W., *The Original Astronomical Observations made in the course of a Voyage to the North Pacific Ocean* . . . London, 1782.
Beaglehole, J. C., *The Journals of Captain Cook on his voyages of Discovery*, Cambridge, 1955–69.
Beaglehole, J. C., (ed.), *The Endeavour Journals of Joseph Banks*, Sydney, 1962.
Beaglehole, J. C., *The Life of Captain Cook*, London, 1974.
Callaghan, F. R., (ed.), *Science in New Zealand*, Wellington, 1957.
Cruise, R. A., *Journal of a ten months residence in New Zealand*, (1820), ed. A. G. Bagnall, Christchurch, 1957.
Dieffenbach, Ernst, *Travels in New Zealand*, London, 1843.
Earle, Augustus, *Narrative of a nine months residence in New Zealand in 1827*, London, 1842.
FitzRoy, Robert, *Narrative of the surveying voyages of His Majesty's Ships* Adventure *and* Beagle *between the years 1826 and 1836*, London, 1839.
Gibbs, W. J., *The origins of Australian meteorology*, Canberra, 1975.

Hoare, Michael E., in *In search of New Zealand's scientific heritage*, Bulletin 21, Royal Society of New Zealand, 1984.
Helm, A. S., and J. H. Miller, *Antarctica*, Wellington, 1964.
Ingram, C. W. N., *New Zealand shipwrecks 1795–1970*, Wellington, 1972.
Kerr, I. S., *Campbell Island — A history*, Wellington, 1976.
Kidson, Isabel M., *Edward Kidson*, Christchurch, 1941.
McCaskill, L. W., *Hold this land. A history of soil conservation in New Zealand*, Wellington, 1973.
McIntyre, D. P., (ed.), *Meteorological challenges. A history*, Ottawa, 1972.
McLintock, A. H., (ed.), *An encyclopedia of New Zealand*, Wellington, 1966.
McNabb, Robert, *Historical records of New Zealand*, Wellington, 1914.
Poole, A. L., *Catchment control in New Zealand*, Wellington, 1983.
Reid, William, *The law of storms*, 1838.
Rendel, David, *Civil aviation in New Zealand*, Wellington, 1975.
Ross, John Clark, *A voyage of discovery and research in the southern and antarctic regions during the years 1839 to 1843*, London, 1847.
Ross, J. M. S., *Official history of New Zealand in the second world war. Royal New Zealand Air Force*, Wellington, 1955.
Shaw, Sir Napier, *Manual of Meteorology*, Cambridge, 1930.
Swainson, W., *Auckland, the capital of New Zealand*, London, 1853.
Swainson, W., *Observations on the climate of New Zealand . . '* London, 1840.
Thomson, A. S., *The story of New Zealand*, London, 1859.
Tudor, Judy, (ed.), *Pacific Islands year book and who's who*, 9th edn, Sydney, 1963.
Wales, William, and William Bayly, *The original astronomical observations made in the course of a voyage towards the South Pole and round the world . .* London, 1777.
Wilkes, Charles, *Narrative of the United States exploring expedition during the years 1838, 1839, 1840, 1841, 1842.* Philadelphia, 1845.
Yate, William, *An account of New Zealand and of the formation and progress of the Church Missionary Society's mission in the northern island*, London, 1835.